Bulletin of the Atomic Scientists

A MAGAZINE OF SCIENCE AND PUBLIC AFFAIRS

VOLUME XVI · NUMBER 10
DECEMBER · 1960
PRICE SIXTY CENTS

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Letters to the Editor

Deeds, Not Words

DEAR SIR:

There are many excellent points in your editorial "The Atomic Age Doctrine—Common Efforts for Common Aims" (October 1960). In fact, I agree with all that you said, but there is one thing which troubles me: if we are to speak from "great moral strength" when we appeal to other nations to follow our example, how will our words square with our actions?

Can we engage in the arms race with utmost vigor, as Chester Bowles and others apparently feel, at the same time that we are "furthering the interests of all mankind" in other ways? Do we demonstrate a concern for men when we stand ready to blow up ourselves and countless men, women, and children in other countries through our "second strike" capacity?

What is the effect of our military focus on our institutions and foreign policy; why is our foreign policy sterile and our disarmament policy ill-prepared? Not only because we do not have a leader in the White House, or have the wrong goals, but because our *stated* goals of peace and freedom for all men are subverted by the logic of our military struggle with Russia.

Saying that we will change the focus of our efforts or restate our goals isn't enough. But moving away from the arms race in practice as well as in words might give some substance to our desire to build trust, to help mankind achieve its common goals. I propose that steps such as the following be taken by the United States on its own initiative; that these steps be accompanied by the program that you have outlined; and that this new direction of American policy be publicized as widely and vigorously as possible:

1. Permanent ending of nuclear weapons tests, inviting U.N. inspection based upon the inspection system under consideration (and partially agreed upon) at the Nuclear Test Ban Conference in Geneva.

2. Systematic dismantling of thermonuclear weapons stockpiles, under U.N. inspection, with these materials being given to the international Atoms-for-Peace program.

3. Ending production and research on CBR weapons, and converting of these facilities to positive work in medical research.

4. Declaring a moratorium on United States missile testing while inviting cooperative international research on the peaceful exploration of space.

5. Unequivocal denial of all nuclear weapons and weapons systems to all countries now included in nuclear weapons systems with the United States.

All other nations should be invited to join in these actions, which must be accompanied by a program of overseas economic and technical assistance channeled through the U.N.; by measures designed to ameliorate the economic dislocations which might result from such a program; by U.N. action to neutralize areas of tension such as Germany and Formosa; and by action to bring China into the world community.

A radical change in policy is necessary to meet the crisis of the armaments race, as well as to meet the challenges created by the struggle of men all over the world to realize a better life. Only by deeds, not words, can we hope to achieve this radical change—deeds which strike at the heart of our profoundly negative and immoral policy of armaments buildup.

I know that the policies proposed are risky. However, I believe that the risks are far less great that those inherent in our present headlong participation in the arms race—and it *is* a program which is consistent with our oft-stated belief that men are endowed with certain inalienable rights among which are *life*, liberty, and the pursuit of happiness.

ANNE M. STADLER

Seattle, Washington

Siting of ICBM Bases

DEAR SIR:

As a geologist who works in several Western states, I puzzle over the illogical complacency of most urban citizens of the Rocky Mountain West while ICBM bases are built practically in their backyards. Recently, however, I have been a bit encouraged by signs that a small per cent of more thoughtful Americans do not want their homes placed in what are sure to become primary H-bomb target areas in the event of atomic war.

In several desert areas where I do geological exploration, I often walk for days without seeing another man. Yet we are crowding our ICBM bases into the biggest target areas in this spottily inhabited part of our country, around cities that usually lie in our most productive agricultural valleys. Shortsightedly, most local merchants and Chamber of Commerce leaders strive to draw these primary atomic war targets to their communities.

Almost everyone I know has given up real hope for the international control of atomic weapons. So perhaps one of the most useful services that the *Bulletin of the Atomic Scientists* can perform today is to repeat again and again the grim facts of the atomic age as they relate to increasing the number of survivors of an atomic war. This factual repitition can prove useful: the little New Mexican town of Artesia, 44 miles from Roswell and its expanding ICBM base, has started to build America's first combined underground elementary school and fallout shelter.

Surely one of the simplest ways to increase the survival chances of millions of Americans is for our commercial and military authorities to start siting our ICBM bases as far away as possible from our urban areas.

CRESSON H. KEARNY

Montrose, Colorado

The Editor welcomes letters on subjects arising out of articles printed in the Bulletin, *but reserves the right to shorten letters for reasons of space.*

Meaning of Freedom

DEAR SIR:

Karl Popper proposes as a rule of method, "Always take the theory you criticize in its strongest, not its weakest, form." Professor H. J. Muller, in the fourth section of his article in the October 1960 issue, follows the opposite maxim. The only alternative he sees to his strictly deterministic theory of choice is the absurd extreme that decisions are made "irrelevantly and unpredictably, that is, in meaningless ways"—and then he innocently inquires, "Why should we desire that sort of chaos?"

No intellectually competent person does desire it. A child could see that there is room for intermediate possibilities between absolute order and absolute disorder. Nor is it a question of "dualism." There are three possible positions: in all cases, in no cases, or only in some cases (those involving human choice), causality involves transcendence. Only the last position should be called dualistic.

Physics seems to find an aspect of individual indeterminacy on the ultramicro level; it is not unreasonable that there might be other levels and higher degrees of the same principle. Professor Muller

(*Continued on inside back cover*)

BULLETIN OF THE ATOMIC SCIENTISTS

Founded in 1945 by
Hyman H. Goldsmith and
Eugene Rabinowitch

Vol. XVI **December 1960** **No. 10**

Bulletin of the Atomic Scientists. Published monthly (except during July and August) by the Educational Foundation for Nuclear Science, Inc., 935 E. 60th St., Chicago 37, Illinois. Entered at the Chicago, Illinois post office as second-class matter.

Editorial correspondence and manuscripts (in duplicate) should be sent to BULLETIN OF THE ATOMIC SCIENTISTS, 935 E. 60th St., Chicago 37, Illinois.

Advertising correspondence should be addressed to Advertising Manager, BULLETIN OF THE ATOMIC SCIENTISTS, 935 E. 60th St., Chicago 37, Illinois.

Subscription correspondence should be sent to BULLETIN OF THE ATOMIC SCIENTISTS, 5750 Ellis Avenue, Chicago 37, Illinois. Printed and distributed by The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Illinois. The Cambridge University Press, Bentley House, 200 Euston Road, London, N.W. 1, England, is an authorized agent for the British Commonwealth, except North America and Australasia.

Change of address. Subscribers are requested to notify the Press and their local postmaster in advance of change, giving both new and old addresses.

Subscription rates for U.S.A. and possessions: 1 year, $6.00; 2 years, $11.00; 3 years, $15.00. Canada and Pan American Postal Union: 1 year, $6.50; 2 years, $12.00; 3 years, $16.50. All other countries: 1 year, $7.00; 2 years, $13.00; 3 years, $17.50.

A Report on Antarctica

A. P. CRARY

THE continent of Antarctica has been the subject of a vast continuing scientific exploration program in the past four years, starting with the International Geophysical Year program of July 1, 1957 to December 31, 1958. The geophysical advances that have been made during these four years both in scientific knowledge and in logistic knowledge have been paralleled only by the space satellite program. In both areas of geophysical studies the operations have continued past the period of the International Geophysical Year without diminution, though with changes to fit the new circumstances.

Prior to the IGY period, Antarctic discoveries, geographical and scientific, were gained through spasmodic expeditions; some private, some governmental, with priority naturally enough on the geographical exploration of the continent. The advance of geographical knowledge of the continent received its greatest impetus with the use of the aircraft in the late twenties. Despite the importance of discoveries of a geographical nature, scientific achievements of the earlier expeditions were not insignificant, spanning the period from 1830 when the American geologist, Eights, discovered the first known fossils of the Antarctic, to 1949, when the Norwegian-British-Swedish expedition, with its international aspects, inland journeys, and completely scientific program set the stage for the vast IGY program.

The IGY operations were fitting sequels to the First Polar Year of 1881–83, and Second Polar Year of 1932–33. The expansion from the north polar concept to a world-wide program reflected the advancement of knowledge, mobility, and communication during the last 25 years. However, to have a world-wide program, great emphasis had to go to the southern hemisphere, and with about 29 per cent of the land area south of the Equator, the Antarctic continent became most important. Also the Antarctic continent contained the south geographic, magnetic, and geomagnetic poles, all important in the studies of the physics and chemistry

of the upper atmosphere. In keeping with the international aspects of the IGY, amicable agreements on the optimum sites and operational cooperative problems of the continent were worked out between the ten nations interested in the Antarctic: Argentina, Australia, Belgium, Chile, France, New Zealand, Norway, United Kingdom, United States, and the USSR. Altogether, nearly 50 stations were established on the continent or on islands of the Antarctic seas, although about half of these were on the attractive Palmer Peninsula area where Argentina, Chile, and the United Kingdom had conflicting national claims.

In the United States, the National Committee for the IGY at the National Academy of Sciences formed the Antarctic Committee under Dr. L. M. Gould to coordinate the scientific work, and consider the vast problems of setting up the U.S. facilities. The U.S. Navy, with its long history of interest in the Antarctic, was given the task of furnishing the required logistics, and Task Force 43, under Antarctic veteran Admiral George J. Dufek, was formed for this. The most outstanding work of the IGY years was the work of Task Force 43 in setting up seven U.S. bases, five scattered along the shores of the continent: Little America, McMurdo, Hallett, Wilkes, and Ellsworth; and two well inland in the heart of the continent: Byrd Station on the plateau of West Antarctica and the Pole Station at the geographic south pole. The successful installations of these two bases, which were fully equipped and fully manned with all IGY disciplines, probably represent the greatest achievement to date in Antarctica. To install and supply these bases, the help of the U.S. Air Force was enlisted and the giant Globemasters, flying from New Zealand directly to McMurdo

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Sound where airstrips had been prepared on the sea ice, paradropped tons of equipment to these inland sites. To reach the Byrd Station, a tractor trail had been scouted out from the Little America Station on the coast, and several tractor trains hauled supplies inland, assisting the paradrops of supplies by the Globemasters. For the other shore stations, ice-breakers led cargo ships through the sea ice with their loads of fuel, food, buildings, and scientific equipment. The USSR also had agreed to establish two inland stations in the heart of the high area of East Antarctica. Working from their main base at Mirny, and without the benefit of the big cargo planes, the Soviets worked their way slowly into the continent by tractors, and with the use of sub-stations enroute were finally able to establish the Vostok Station near the south geomagnetic pole. During this year they also reached the heart of the continent at the so-called Pole of Inaccessibility, though no wintering party has operated there. A small inland station was also established by the French for the IGY about 300 kilometers inland from their main coastal station, though it has not been occupied since the IGY period.

Considering the tremendous effort that had gone into the building and supplying of the Antarctic stations, it was obvious that the work should continue after the IGY period, and plans were under way for this continuity very early in the IGY days, through the international antarctic committee that was formed—the Special Committee for Antarctic Research, SCAR. For the United States, the scientific programs have remained at about the same manpower level, although one base, the Little America Station, was closed down, and administrative responsibilities for the Ellsworth and Wilkes Stations were transferred to Argentina and Australia, respectively. The additional personnel to make up for the cutback of stations came from the disciplines of biology, geology, and cartography which had not been supported during the IGY period, and from the addition of a scientific staff at McMurdo Station. A major change in the mode of scientific operation has been the increased air flights from New Zealand to McMurdo, and summer personnel of the glaciological, biological, and geological disciplines can now fly to the continent in October or November and return in January or February. Wintering-over efforts continue, of course, for the continuous recording programs of meteorology, seismology, and upper atmosphere physics. The 1959–60 summer scientists numbered 51, while there were 35 wintering personnel in 1960. The U.S. Navy, furnishing logistics personnel for the operation of the bases and air crews for the flying operations, requires several times the number of the scientific personnel. Since the IGY operation, the administration of the scientific Antarctic program has been taken over by the U.S. Antarctic Research Program office of the National Science Foundation under the direction of Dr. T. O. Jones. The National Academy of Sciences continues to cooperate with its Committee on Polar Research which assists in the evaluation of the scientific work and long-term program guidance. It also represents the United States in the international group of SCAR. At the National Science Foundation, the proposals for Antarctic work from government agencies, universities, or private concerns are reviewed, and these programs, if accepted, are coordinated and integrated as necessary for the Antarctic operations.

Scientific Programs

All United States efforts in Antarctica are presently directed to scientific studies, and the scientific gains have been so numerous that no attempt will be made here to do more than relate some of the highlights and to outline the general scope of the efforts.

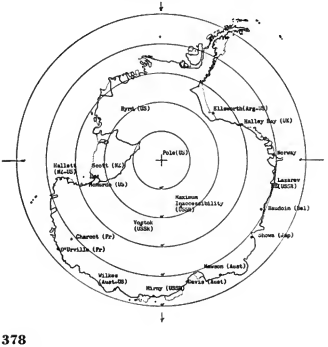
Biological and Medical Sciences—Biological programs were not included in the official IGY studies, but beginning with the Antarctic summer of 1958–59 the interest has increased steadily, and now 13 various agencies have programs with a wide range of biological problems. The main area of investigation has been at McMurdo Sound where a complete biological and medical laboratory has been established, and is now supplied and operated by Stanford University. Investigations in the McMurdo Sound area include the study of land invertebrates and their adaptation to climatic conditions by scientists from the University of Tennessee; study of the size, age, growth, and metabolic rates of Antarctic fish and inshore marine invertebrates by Stanford University; study of the airborne organisms by the Bernice Bishop Museum; investigation of water metabolism of the penguin with emphasis on the role of sea water and salt in the food by researchers from Duke University; study of the parasites of Antarctic vertebrates and invertebrates by the Virginia Fisheries Laboratories; collection, isolation, and identification of airborne microbiological organisms by the University of Texas; ornithological studies in the little-known Bellingshausen Sea area by a scientist from the American Museum of Natural History; continual banding of Antarctic birds monitored by Johns Hopkins University; and study of the sexual, parental behavior, and the orientation mechanisms of the Adélie penguin by the University of Wisconsin. Medical programs have included studies of upper respiratory tract infections prevalent in personnel in the Antarctic following isolation, and psychological studies of group behavior of Antarctic isolated parties, this latter by George Washington University. New biological programs that will be initiated in the near future include the study of endogenous rhythms at the South Pole by the University of California; biological investigation of fresh water lakes of Antarctica by the University

of Kansas; and Antarctic microfauna by the Kaiser Foundation Research Institute.

Cartographic Studies—As the vast logistics problems of supplying the Antarctic bases become more routine, the U.S. Navy has been able to accomplish more aerial photography for mapping. Ground control for this mapping has been continued on the glaciological traverse programs wherever possible by topographic engineers of the U.S. Geological Survey. The main concentration of mapping has been in those particular areas where geological investigations are planned.

Geology—As with the biological program, geology was not considered a geophysical science and was not given funds during the IGY years. However, many reconnaissance parties were able to make collections and brief studies in the areas visited by oversnow parties, and brief reports of the rock character in the vicinity of the Wilkes Station, of the Dufek Massif of the Pensacola Range, in the Sentinel Mts., the Horlick Mts., and the Executive Committee Range have been made. In the summer of 1960–61 for the first time, extensive operations will be attempted by four different agencies; the University of Minnesota, the University of Wisconsin, the Ohio State University, and the U.S. Geological Survey in western Antarctica in the Horlick Mts., the Sentinel Mts., and in the coastal ranges near the Amundsen Sea and the Thurston Peninsula. In the McMurdo Sound area, easily accessible for U.S. parties, there have been continued studies for the past two seasons by geologists from the U.S. Geological Survey, Tufts College, and the University of Kansas.

Glaciology—It is only natural that the study of the ice of Antarctica should have high priority since this study reveals the description of the main features of Antarctica. This work has centered on oversnow trail operations away from the bases during the summer seasons. The U.S. teams, in 8 programs, have covered over 16,000 kilometers of inland ice. Together with the similar work of other nations, charts can now be made up of the elevations of Antarctica, the ice thicknesses, and of the continent without its extensive ice cover. Elevations were found to be 2,000 to 2,500 meters above sea level in that part of the continent called West Antarctica, and generally included in the West Longitude lines; while the surface of East Antarctica lies 2,500 to 4,000 meters above sea level, and consequently the climates are much more severe. The average ice thickness values for the approximately 13 million square kilometers of Antarctica have been estimated at about 2,000 meters. Without the snow cover, the main features of interest are the large sub-ice channel between the Ross Sea and the Bellingshausen Sea, and the vast area of East Antarctica whose underlying rock surface is near sea level, with the exception of some ranges, well above sea level, that were studied by Soviet scientists.



Another item studied extensively by the glaciologists has been the average annual net accumulation. That this is quite low, averaging perhaps 8 or 9 centimeters water equivalent, should not be surprising considering the high elevations and extreme climate. Some low-lying areas, however, may have as much as 40 cms. of water equivalent annually while some of the high plateau areas of East Antarctica may receive only a few centimeters. Whether or not this average accumulation is offset by ice flow from the continent has been the subject of much controversy, but the continent is generally considered to be in balance, within the limits of the present knowledge.

Deep drilling programs have been conducted by the U.S. Army's Snow, Ice and Permafrost Research Establishment, and ice cores to 300 meters have been obtained at the Byrd Station and to 250 meters at the Little America Station. The densities and temperatures obtained from this operation have already contributed much to our knowledge of the character of ice behavior, and studies that are now under way of the microparticulates should give details of our environmental history back for several thousand years. Plans are under way for more extensive drilling programs that may be able to drill through the complete ice cap.

Meteorology—The meteorological data collections in Antarctica for the United States have been obtained by the U.S. Weather Bureau and aerologists from the U.S. Navy. The main efforts have been, and continue to be, the synoptic upper air observations of temperature, pressure, humidity, wind speeds, and wind directions as observed twice daily with rawinsonde balloon flights. Surface weather observations are also made every

three hours, and additional observations related to energy balance studies have been extensive.

The International Antarctic Analysis Center, initially located at the Little America Station, was transferred in 1959 to Melbourne, Australia. Here current weather charts for various levels are prepared for the use of operating groups. Current research efforts are also under way by the U.S. Weather Bureau on various aspects of Antarctic circulation and horizontal energy transfer.

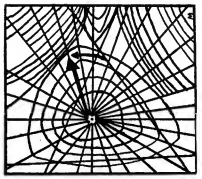
Oceanography—Despite the great volume of waters surrounding the Antarctic continent, U.S. contributions to Antarctic oceanographic research have not been extensive. The only vessels available have been the icebreakers and they are not fitted for research work, nor can they deviate extensively in time or place from their primary tasks of supplying the Antarctic bases. However, studies of temperatures and salinities with depth, plus routine coring and depth measurements have been made where possible by the U.S. Hydrographic Office observers. At present an oceanographic research program is in progress through the ice of McMurdo Sound.

Earthquake Seismology—At all United States stations except McMurdo Sound, seismographic equipment has been installed and is in current operation either by the U.S. Coast and Geodetic Survey, the Lamont Geological Observatory of Columbia University, or California Institute of Technology. Information from these seismograph stations is used by the U.S. Coast and Geodetic Survey in the locations of earthquake epicenters, and, though they have helped considerably in the location of earthquakes in the southern hemisphere, it has been found that Antarctica itself is not a very active seismic region. Some use has been made of the seismographs to delineate Antarctic continental structure and to get details of the microseisms that can lead to information on the extent of seasonal sea ice.

Upper Atmosphere Physics—The studies of the ionosphere layers, the aurora, geomagnetic variations, and cosmic rays were the main programs that prompted the initiation of the IGY program, and with the added attraction of the presence of the south magnetic pole, Antarctica has been the scene of a very active upper atmospheric program.

Aurora observations have included visual aurora studies, all-sky camera photographs, and patrol spectrograph studies operated by the Geophysical Research Directorate of the U.S. Air Force. Analysis of the records has made possible a good definition of the southern auroral zone and many new and interesting discoveries of emission characteristics. As in other upper atmospheric studies, diurnal variations of aurora were found at the South Pole.

Ionosphere observations with the ionosondes have been taken at all U.S. stations except McMurdo by scientists from the National Bureau of Standards. In addition to radio noise studies, whistler and other VLF propagation studies by Stanford University and Dartmouth College have been carried on throughout the period of Antarctic work, and the programs are continually increasing in scope.



Geomagnetic observatories study the short-term magnetic variations which register upper atmosphere physical changes and the absolute magnetic values with their secular changes which are a result of conditions in the interior of the earth. The geomagnetic programs in Antarctica are maintained by the Coast and Geodetic Survey.

Cosmic ray studies are presently under way at Ellsworth Station, monitored by the University of California; at McMurdo Sound by scientists from the Bartol Foundation; and at Hallett Station, where a new program will be started soon by University of Maryland personnel.

Foreign Scientific Programs—Generally, the scientific work of the other countries is of the same general character as that described above for the United States, though cartography and geology have always had high priority with the USSR, U.K., and Australia, and the work of these nations has resulted in extensive and noteworthy surveys, particularly along the coasts and immediately inland in East Antarctica and in the Palmer Peninsula. The USSR, alone among the nations in Antarctica, has made extensive oceanographic researches, usually keeping ships engaged several months after the supply operations have been completed.

International Aspects of Antarctica

Antarctica is the earth's only continent that is isolated by hundreds of miles of open water from its nearest neighbor; and too, it is the only continent without an indigenous human population. The credit for the first discovery of the Antarctic mainland is claimed by three nations; the U.S., the U.K., and the USSR, all based on the interpretation of ancient records of voyagers of 1820. Beginning with the British claims in the Falkland Islands in 1908, there were seven nations with Antarctic claims by the beginning of the IGY in 1957, those of the U.K., Chile, and Argentina in the Palmer Peninsula overlapping. Neither the United

States nor the USSR have made claims nor recognize the claims of other nations.

The IGY was a world-wide operation among scientists of many nations, and there was general agreement among these participating countries that it should be divorced from political considerations. As the bases in Antarctica were difficult and costly to build, and in the cases of the inland stations of the Russians, were not completely established until near the end of the IGY period, continuation after IGY was generally expected. An early proposal by the U.S. to continue the scientific program was adopted and, for the consideration of these post-IGY international scientific studies, the Special Committee on Antarctic Research (SCAR) was organized by ICSU. To date this Committee has met four times, the last being in Cambridge, England, in late August and early September 1960. A fifth session is tentatively planned for late 1961 in New Zealand. SCAR has restricted its discussion to scientific problems: the outline of the scientific programs, the required coordination and cooperation to make these programs more fruitful, exchange of data, and exchange of information on logistic capabilities and logistic plans. It has also continued to promote international working groups such as the International Antarctic Analysis Center in Melbourne, Australia, and to encourage the bilateral exchange of scientists.

On the continent, the U.S. has led the way in international cooperation. From the beginning of IGY, Hallett Station has been a joint U.S.–New Zealand effort. When the IGY was completed, the U.S. Wilkes Station was turned over to Australia for administration, and the Ellsworth Station to Argentina. In both cases the U.S. continues to supply scientists for some of the programs. International cooperation is perhaps best illustrated in Antarctica by the ready assistance that has always been forthcoming for besieged ships or downed plane crews. The capabilities of all nations are available in times of trouble.

In early 1958, the United States proposed to the other nations with interests in Antarctica that they consider a treaty that would keep the continent a scientific laboratory, in effect perpetuating the IGY spirit. Such a treaty was signed on December 1, 1959, and some of the main items reflect the international problems. Antarctica is to be used for peaceful purposes only, that is, there shall be no military bases established, or testing of military weapons. The treaty encouraged the exchange of scientific programs, personnel, and results between nations. No activities under the treaty are to constitute a basis for supporting or denying a claim, nor should a new claim or an enlargement of an existing claim be possible under the treaty. Nuclear explosions and the disposal of radioactive waste material are prohibited. The treaty also makes arrangements for complete freedom of access for all nations to any parts of Antarctica including inspection of bases of other nationals. Provisions are made for meetings after the ratification of the treaty to formulate methods of achieving the main objectives.

This treaty requires ratification from each country according to the various national statutes. The U.S. ratification was made by the Senate in August 1960, though the vote indicated that feelings about the subject were by no means unanimous. For those favoring the treaty, however, it was a step ahead—the first such international agreement that had ever been reached over a complete continent; and implications were that it would prove a most important background for the international legal settlements of the problems of outer space. At the present writing, only a few nations have not ratified the treaty, but it seems only a matter of a few months at most until the treaty becomes effective.

Antarctic Future

With the treaty in process of ratification and thus the status of the continent as a potential source of political conflict removed for the time being, it may be expected that many nations will take a more realistic look at the costs involved in the operations of the bases, and speculate on the true worth of the scientific effort. It is, of course, difficult to put science on a profit-and-loss basis, and experience has shown that the scientific findings that make the most impact on progress of mankind often start from obscure researches. However, in any research field, as demonstrated in the evaluation of data, scientists themselves set a point of diminishing returns for their own time and investment. As researches continue in Antarctica, there must undoubtedly be a point of diminishing returns for many of the programs that, in view of the tremendous costs, will need careful consideration. Certainly, for example, there will be an end to the extensive oversnow traverse operations when their tracks have covered Antarctica with ade-

quate spacing, and there will be an end to major cartographic efforts when the continent has been adequately mapped. But will there be an end to the usefulness of such programs as the extensive (an expensive) meteorological upper air programs? If there are no operational requirements for weather data, would not 10 or 15 years of records be sufficient to have an understanding of the upper air vagaries? There must be some point of diminishing returns here, even though meteorological researchers may deny this. Perhaps information from satellites will eventually replace to a large extent the need for detailed surface and upper air data. The relatively new science of the upper atmosphere physics and chemistry is on a firmer basis since this field is least well known, and the Antarctic, unlike the Arctic, offers a firm land site at the geomagnetic pole area from which to conduct observations. For biology and geology, it might be argued that eventually, in line with the costs, the flora and fauna will be sufficiently studied and the rocks sufficiently chipped—but will there not always be potential values in these studies, particularly of the marine life? Glaciology is a relatively new subject for the U.S. to be concerned with; but in the Antarctic it, in effect, describes the continent. The value of glaciology lies in the study of the behavior of ice flow, since it can be easily determined and can then be extended to materials such as metals and the earth rocks where the time factors involved are many times longer. One of the most perplexing mysteries of this planet is the history of glaciation. The possibilities of future man-made climatology cannot be overlooked but the outline, causes, and results of past changes must come from continued, concerted effort in the combined disciplines of glaciology, oceanography, and meteorology. It would appear that earthquake seismology in Antarctica, by its contribution to the location and character of earthquakes, particularly those in the southern hemisphere, will serve mankind indefinitely. The oceanic area surrounding the continent, and many times greater in coverage, will soon replace Antarctica as the world's least known area. The sub-Antarctic water and its atmosphere are one of the great mediums of heat exchange in the world.

Perhaps the two greatest hopes for Antarctic research are a badly needed Antarctic research ship and polar-orbitted satellites. The research ship seems hopeful and may be on the water in early 1962. Its mission would be the scientific exploration of the sub-Antarctic oceanic area—the upper atmosphere physics, meteorology, oceanography, submarine geophysics, and all phases of biology above and below the water line. Polar-orbitted satellites are not only of great interest to all phases of Antarctic meteorology but should help define the sea ice cover, of great importance to southern hemisphere heat budget studies and also to the operation of surface ships.

There are plans under way for the construction of a nuclear reactor in the near future at McMurdo Station. Fuel in Antarctic forms the main bulk of supplies, and it has been reckoned that a nuclear reactor there, though not commercially practical in the States, would mean a large saving. However, any reactor must have a background that will not interfere with the scientific studies, and its waste disposal problems and safety considerations must satisfy the Antarctic treaty provisions. Whether such a reactor under these conditions, and considering the costs of installation, transportation, and operations in Antarctica will actually result in reduction of operational costs remains to be determined. If practical, they eventually may also be located at the inland stations. Certainly any manner in which the present estimated cost of one quarter of a million dollars per scientific man-year can be reduced would be most welcome. Austerity of living and working conditions, though perhaps a step backward on a national scale, is still generally accepted by the scientific community, and may eventually be the best way to insure a progressive scientific program without exorbitant costs.

Outspoken Scientist

LINUS CARL PAULING

IT IS NOT a new thing for the distinguished theoretical chemist, Linus Pauling, to be embroiled with a congressional committee or government agency. Since the early forties when he refused to fire his Japanese gardener in the days immediately after Pearl Harbor, he has been periodically in the news as the result of speaking out on the unpopular side of important issues. Because he was vice-president of the World Federation of Scientific Workers which has Communists among its members and had in the late forties a Communist president, Professor Joliot-Curie, Pauling attracted the attention of local and congressional groups investigating communism. He was listed by Louis Budenz, a former Communist on the staff of Fordham University, as a member of a group of alleged Communists. This was promptly and flatly denied by Pauling: "The statement is a lie." He was attacked by McCarthy in 1950 as "having a well-nigh incredible record of membership in Communist-front organizations." As the result of these allegations, he was denied a passport three times in 1952 for the purpose of attending scientific meetings and became a cause celèbre. On the fourth try he received a "limited" passport for England and France, but was not allowed to go to India. At the same time, while the gods laughed, his theory of resonance was being denounced at a Soviet chemical conference.

Pauling's scientific career has been brilliant. Born in Portland, Oregon, on February 28, 1901, he received his B.S. from Oregon State College, his Ph.D. in chemistry from California Institute of Technology in 1925. He worked in Munich, Copenhagen, and Zurich in the golden years when the new physics was burgeoning. Perhaps his great achievements in science stem from just this—that as a young modern theoretical chemist he took the trouble to learn physics and quantum mechanics. This opened up avenues of research which paid off splendidly. In the thirties he worked on metal bonds and the nature of metals and then moved on to attack the mystery of proteins. He became known as "a chemist's chemist" when he described the forces which hold atoms together to form molecules as "resonance." Patiently he took proteins apart and showed that their enormous molecules are made of twisted atom chains. His book, *The Nature of the Chemical Bond*, is one of the classics of modern science. In recognition of these discoveries and their application to the elucidation of the structure of complex substances, he received the Nobel Prize for chemistry in 1954.

Pauling's entire working affiliation has been with California Institute of Technology where he became chairman of the division of chemistry and chemical engineering and director of the Gates and Crelin Chemical Laboratories. But he has held many lectureships and visiting professorships in this country and abroad. His list of honorary degrees is long (and includes Chicago, Princeton, Yale, Cambridge, London, Oxford) as is the number of prizes and medals conferred upon him. He is a member of many foreign societies including the Soviet Academy of Sciences. This honor which he shares with Detlev Bronk, president of the U.S. Academy of Sciences, Pauling says was given him because of his outstanding position in the scientific world not because of his test ban petition as the *New York Times* suggested.

There has never been any false modesty in Pauling's make-up. From a young man he was aware of his powers and knew where he wanted to go. His ambitions were fully shared by his wife, Ava Helen, whom he married in 1923. She has literally been by his side every step of the way. It has been a remarkable relationship, a joint enterprise in which she accompanied him to every meeting, conference, speaking engagement, and foreign country, four children notwithstanding.

An achievement of Pauling's not generally known is his conquest of a serious disease, nephritis. With characteristic independence of mind, he applied his knowledge and intelligence to his condition and worked out an approach which was said to be unorthodox but which proved successful.

His recent harassment by the Senate subcommittee on internal security (headed by James O. Eastland, Democrat, Missouri, but conducted by Thomas J. Dodd, Democrat, Connecticut) could have led to a "contempt of Congress" citation with a subsequent jail sentence. It began quietly enough last July with Pauling already in

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Congressional Testing of Linus Pauling

HARRY KALVEN, JR.

•This is the first of two articles on the recent appearances of Nobel laureate Linus Pauling before the Senate Internal Security Subcommittee. It presents the legal framework of Mr. Pauling's encounters with the Committee, reviewing the issues raised by his refusal to answer a particular inquiry, and evaluating the legal case that might have resulted had he been cited for contempt of Congress. The second article will discuss the style and content of the hearings, and the Committee's view of its function and of the decencies of official interrogation. •Harry Kalven, Jr., author of the memorable analysis of the Oppenheimer case in the September 1954 Bulletin, *is a Professor in the University of Chicago Law School.*

Part I: The Legal Framework

ON JUNE 21, 1960 Linus Pauling appeared under subpoena before the Internal Security Subcommittee of the Committee on Judiciary of the United States Senate. Mr. Pauling furnished the Committee with much information about his well-known international petition against nuclear testing including a list of signers, his various press releases, an account of its origin, an estimate of its cost and who had paid for it, and finally a list of those to whom he had written for help in collecting the signatures. He refused, however, to turn over the correspondence he had received from those he solicited, or to say how many signatures each respondent had supplied. He made it clear that he objected in principle to the Committee's inquiry and doubted that the Committee constitutionally had the power to compel him to comply with their request. At the conclusion of the hearing Mr. Pauling was ordered to appear again on August 9th and to bring with him the information he had refused to give.

Mr. Pauling proved, as would have been expected, to be a strikingly able and articulate defender of his position. Considerable publicity attended the first hearing and Mr. Pauling made a determined but unsuccessful legal effort to have his rights adjudicated in the courts prior to the second hearing, taking his case all the way to the United States Supreme Court. There was every expectation, therefore, that the second hearing would provide a dramatic showdown and would generate a legal controversy of considerable importance.

After several continuances, the second hearing took place on October 11. The dramatic showdown turned out to be something of a dud. Early in the hearing Mr. Pauling stuck to his guns and refused to turn over the information. The Committee, however, appeared to have changed its position somewhat and when Mr. Pauling declined the Committee request, the Chairman, Senator Dodd of Connecticut, merely said "Very well" and significantly did not order Mr. Pauling to answer. The Committee thus appeared to have deliberately avoided laying the necessary legal predicate for a contempt citation of Mr. Pauling. The legal prediction at this point would be that the Committee cannot now on this record move to have Mr. Pauling cited for contempt of Congress and that the case as a legal controversy is over.

Did the Committee Hit and Run?

Since the legal rules requiring an unequivocal command to the witness to answer before contempt can occur were presumably well known both to the Committee and its counsel, the conduct of the Committee can only be interpreted as a voluntary and deliberate relinquishing on its part of its chance to cite Mr. Pauling for contempt.

At this point both sides could plausibly claim victory. Mr. Pauling successfully refused to tell the Committee any more than he wished to, and in this sense won the point of principle on which he had rested his resistance. The Committee, however, did not yield on whether its question was proper, and thus placed Mr. Pauling in the possibly awkward public position of having refused to tell a government authority some facts about the organization of the petition. It went on to interrogate Mr. Pauling for several hours after his refusal to answer the one question, and thus succeeded in exploring in a highly

public fashion and on a public record the details of the organization and promotion of the petition.

Granting that interpretation of motives in such matters is treacherous, I would interpret the Committee's sensible resolution of the controversy not so much as an act of generosity but as a deliberate effort to avoid finding out whether it had the legal power it pretended to have. Senator Dodd may be all for continuing nuclear tests of government military power; he is, I suspect, less enthusiastic about constitutional tests of congressional investigatory power.

While, as a lawyer, I cannot down a slight twinge of regret that the Committee did not cite Mr. Pauling, and thus provide the courts with a major case in which to measure committee powers, it is clear that this was a happy and sensible solution. There is a great difference between the question whether the Committee *could* have sent Mr. Pauling to jail for refusing their request and the question whether they *should* do so. The first is an issue of constitutional law and is strictly for the law to handle; the second is a question of administration and is very much for the Congress to handle, as a matter not of law but of practical wisdom. Congress need not always exercise its power to cite a recalcitrant witness. The Pauling case is thus at the outset an impressive precedent for the exercise of congressional discretion.

What is Left to Discuss?

Although the Committee has thus successfully put out the legal fire, and the case can no longer be viewed as an angry cause, there is much in it which merits attention now. The importance of the case does not reside in the fact which first catches the eye—that the United States government came so close to sending one of its more distinguished scientists, a Nobel laureate, to jail —but in the fact that the case would have put to the law an issue of extraordinary interest and significance. In addition, the hearings themselves deserve to be reported in some detail as a classic example of the distasteful official ceremony a congressional investigation has become so often today. There are a variety of grounds on which a committee may be challenged legally, none of which have thus far been markedly successful. The Pauling hearings raise arresting issues in connection with almost all of these, but particularly with respect to what is perhaps the most edifying and least technical basis for challenge, namely, that the inquiry itself is a violation of First Amendment protections of the freedom of speech, assembly, and petition. No case has yet held that a congressional inquiry did violate the First Amendment. Mr. Pauling's case would have put the First Amendment challenge to the courts in its strongest possible light.

The Power of the Committee

Headlines during the past decade have created a loose public impression of the nature of a congressional investigation. It is well, therefore, to begin with the simple legal profile of what a committee can and cannot do. All that it can do is to compel a witness to testify. If he talks, and talks honestly, that is the end of the matter. The Committee has no power to deal with him further; it is not adjudicating or determining any of his rights or duties; it is simply collecting information for legislative use. If a witness does not answer honestly, he may expose himself to a perjury prosecution; if he refuses to answer at all, he may expose himself to a contempt prosecution.

As the law now stands, the witness has one method of testing committee power. He can refuse to answer particular questions and risk citation for contempt, which is a statutory crime. In the trial for contempt the witness can get judicial review of the committee's power. He can, that is, find out whether the committee has the power to compel him to answer that question—and frequently now the courts have intervened in contempt cases and held that the committee exceeded its power.

Before we turn to the substantive grounds on which the power of a committee may be legally challenged, there are two preliminary aspects which require brief attention, particularly in the light of the Pauling facts. The points are: (1) whether it matters that the witness reasonably thought he had a good legal case and was not simply recalcitrant and (2) the proper role of the parent house of Congress in reviewing contempt citations.

The Motives of the Witness

The law holds that the witness declines to testify at his peril—his motives are immaterial. If, as in the recent case of teacher Lloyd Barenblatt, the witness declines out of a genuine doubt that the committee has the legal power, and even if his point is good enough legally to win the support of four dissenting justices of the United States Supreme Court, he has nevertheless committed the crime of contempt and his status is no better than if he were flagrantly recalcitrant.

It was to avoid the harshness of this rule that Mr. Pauling initiated his series of legal moves after the first hearing to force adjudication of his rights prior to the second hearing, so that when he testified in October he would have had the advice of a court as to his legal position. Mr. Pauling sought a declaratory judgment in the federal District Court in Washington that he did not have to answer the committee request. This effort by Mr. Pauling ranks as a creative legal attempt to clarify the witness's position and to reduce the risks the law now forces him to take. However both the District Court and the Court of Appeals for the District of Columbia decided against him. An appeal to the United States Supreme Court was pending at the time of the second hearing. These decisions applied to the merits of the procedural move and did not in any way judge the merits of Mr. Pauling's objection to the Committee. The courts decided simply that the controversy between

Mr. Pauling and the Committee had not yet become sufficiently focussed and mature to permit adjudication.

Congressional Ratification of Contempt Citations

Under the law, once the Committee recommended contempt, the question would have come back to the Senate. Unless the Senate itself voted the contempt citation, there could have been no prosecution of Mr. Pauling. There has thus been placed in the basic procedure an important safeguard, a chance for the appropriate house of Congress to supervise and check the conduct of its committees. In recent years, however, the ratification has become perfunctory and has produced little or no debate, but there was a good chance that had Mr. Pauling's case reached the floor of the Senate, it would have produced a memorable debate and just possibly a refusal by the Senate to vote the contempt.

There has been some difference of opinion in Congress as to the propriety of rejecting a committee contempt citation on the ground that it would be taking over the function of the courts. This seems to me a seriously mistaken view. The question is not primarily whether the Committee's conduct was legal, but whether it was wise—and Congress is the proper arbiter of that question. It would be well to have the courts continue with efforts to regulate committees but it would be best to have Congress exercise control itself. And the chance to scrutinize contempt citations is perhaps the best chance Congress has to exercise some responsibility.

Five Points of Challenge to Committee Power

Turning now to the substantive grounds on which a committee can be challenged, we revert to the simple legal profile of an investigating committee. Realpolitick would seem to have added another dimension to the profile. The major congressional committees have been inextricably tied in with publicity, and this publicity, with the full prestige of the government behind it, has often exposed witnesses to a hostile public response. The inquiry itself has appeared to engender extralegal sanctions and, in the view of some critics, to become de facto a sort of trial by publicity. Thus it has been argued that there is much more to a congressional inquiry than the placid legal description of it as the orderly collection of information for legislative use suggest. A variety of legal grounds for challenge have been developed by now, some of which rest on the realistic view of what a committee in actual operation is and some on a more technical basis.

For present purposes it is sufficient to note five grounds on which a witness may refuse to answer a question: (1) that under the Fifth Amendment he is privileged not to answer questions which tend to incriminate him; (2) that Congress had not authorized the committee as an agent of Congress to ask the question; (3) that the question was not pertinent to the matter under investigation and hence outside the statutory definition of contempt which defines the crime as the refusal to answer pertinent questions; (4) that the inquiry was not in fact in aid of legislative function but was for the sake of exposure or some ulterior purpose; (5) that the inquiry, coupled with the compulsion to answer it, is government action in violation of the First Amendment.

The Fifth Amendment Challenge

The most widely publicized grounds of challenge to congressional committees has been the claim of the privilege against self-incrimination under the Fifth Amendment. Since Mr. Pauling did not base his refusal on a claim of the privilege, it need not long detain us, although the career of this famous Anglo-American privilege in congressional inquest would be worthy of a full essay in its own right. In brief the story is a sad one. Since the claim of the privilege has been widely interpreted as raising a serious suspicion about the witness, he escapes the contempt citation at the price of being taken by the public to have virtually admitted the incriminating part of the question. The privilege has thus proved to be almost completely self-defeating. Perhaps this result was inevitable, given the quixotic quality of the privilege, and ambiguity as to just what evil it was designed to protect witnesses from. The paradox of the privilege has become so complete that the main fact-finding achievement of the committees investigating subversion has been the locating of people who claim the privilege of not answering their questions. But all this has nothing to do with Mr. Pauling. The controversy turns on the propriety or rational necessity of drawing some negative inference from its being claimed, and on this point there is genuine legal dispute. It is important and relevant for the Pauling case that if the witness refuses to answer on grounds other than the Fifth Amendment, there is no basis for drawing any sort of negative inference from his refusal. On this point there is no legal dispute, and on this point there should be no public misunderstanding.

The Authorization Challenge

Since the investigative power originally rests in the full Congress and not in the committee, Congress must have authorized the investigation which the committee undertakes; the issue is simply one of what Congress intended when it set up the committee. Nevertheless, the point has, at times, proved congenial to the legal mind. In the 1953 Rumely case, the Supreme Court held that the House committee authorized to investigate lobbying was not authorized to ask the distributor of conservative economic tracts to furnish the names of people who had bought books from him. Since the committee had not been authorized to ask the question, Mr. Rumely could not legally be held in contempt for his refusal to answer it. A gratifying number of contempt cases from Senator McCarthy's committee on government operations were lost, when they finally reached the courts, on

precisely this point. The courts discovered that the Senate had never authorized the variety of inquiries into subversion which the Senator so energetically undertook, and that the Senator, who in his heyday appeared to be almost omnipotent, had in fact been operating without any legal power to compel the testimony he was so dramatically seeking.

In Mr. Pauling's case, a fairly good argument could be built that the Senate Committee was not authorized to investigate the Pauling petition. The argument would rest on an analogy to the 1953 *Rumely* case; on the fact that the great democratic privilege of petitioning government was involved; and finally on the fact that the petition was not addressed to the government of the United States but to the United Nations and that a majority of the signers were citizens of foreign countries.

The Pertinency Challenge

Pertinency derives from a limitation in the contempt statute itself that the question must be pertinent to the matter under inquiry. It must be sufficiently clear to the witness and to the court what the topic of inquiry is, so that the witness can judge the pertinency of the question at the time he is asked and so the court can review the issue. Otherwise contempt for refusal to answer pertinent questions becomes an unconstitutionally vague crime. But lack of pertinency is easily remedied; it can sometimes be cured merely by a subcommittee resolution, by the opening statement of the chairman, or even by the chairman's reply to a challenge from the witness as to why the question was being put.[1] Pertinency is thus a slender reed. In any event Senator Dodd made it clear at the opening of the first hearing that "the particular objective of the session today is to learn what we can from the witness respecting Communist activity in connection with protests against nuclear testing."

The Challenge to Legislative Purpose

This objection is less technical, and turns on whether there is a legislative purpose behind the inquiry on behalf of which the information is being solicited. Since some of the celebrated congressional investigators have openly boasted of bringing individuals into the "pitiless spotlight of publicity" etc., many serious efforts have been made to challenge the legislative purpose behind the inquiry. It may seem surprising that this point has proved so uniformly unsuccessful in the courts. The courts, while steadfastly repeating the formula that there must be a legislative purpose, and that intrusion into private affairs is not permissible, have been equally steadfast in their refusal to look beyond the congressional authorization for evidence of a bona fide purpose. They have not permitted the committee members to impeach the committee by their own words. If the authorization is proper, the committee is conclusively presumed to be engaged in a legislative inquiry. Ironically it is the very separation of powers doctrine, under which courts are to try individuals and legislatures are to legislate, which both gives the objection its force and makes it impolitic for a court to respond to it. The courts simply will not, and perhaps really cannot, assess the true motives of a coordinate branch of government.

Occasionally, however, the argument has centered less on the realpolitick of committee activity than on an effort to show that no valid legislation was possible under the circumstances, and that hence there could not be a valid legislative purpose behind the investigation.[2] This point has also fared badly in the courts, which are unwilling to prophesy all possible forms of legislation that a particular inquiry might stimulate.

The Pauling case might have given vitality to this argument in both of its forms. There is first the disturbing fact that Senator Dodd happens to be a leading public spokesman for a position on nuclear tests which is diametrically opposed to Mr. Pauling's. The investigation could be read as primarily an effort by the Senator to help his side of the debate. It is not clear from the record of the hearing that Senator Dodd and the other members of the committee had any such purpose in mind. There are eloquent disclaimers by them in the record of the hearing, and Senator Dodd seems a little unsure throughout just what the purpose of the whole thing is. There is, therefore, a kind of engaging bumbleheadedness about it all which disarms one.

But there is also the question of what kind of legislation Congress could conceivably enact in this area. This is troublesome both because the great right of petition, which would be difficult to circumscribe constitutionally, is involved; and because the whole matter appears to be beyond United States jurisdiction as the petition is addressed to the United Nations. The answer that Congress might at least decide to regulate this type of lobbying by requiring disclosure of the names of organizers of such petitions is dubious in the light of the *Rumely* case and of current doctrine as announced in the recent *Talley* case that an ordinance prohibiting distribution of anonymous pamphlets was unconstitutional.

The First Amendment Challenge

We come then to the final challenge—that the inquiry

[1] In the 1957 *Watkins* case, the Supreme Court appeared to give great power to the pertinency limitation in reversing the contempt citation of a labor leader who, after testifying fully about himself, refused to discuss a list of some thirty names of others he was alleged to have known several years before. However, the *Barenblatt* case, in which the Supreme Court upheld a similar contempt citation, appears to have taken most of the momentum out of the *Watkins* ruling.

[2] There is still another important variant on the legislative purpose challenge which the Pauling case does not illustrate. Although the committee often has a genuine topic of inquiry, it fails to lay any basis for thinking that the particular witness called could provide them with relevant and needed information. Hence, there would appear to be no legislative purpose in calling this witness. This point is latent in the *Braden* and *Wilkinson* cases, which are now pending before the U.S. Supreme Court.

itself is unconstitutional under the First Amendment. The precise legal issue has proved tantalizing indeed, and requires careful statement. It is not at once apparent that compelling a man to testify to the truth is an interference with free speech. Two steps are involved. First, the sense in which the inquiry is a restraint on speech; and second, assuming that some restraint can be identified, the standard by which the constitutionality of such restraint can be measured?

The restraint, although not easy to spell out with precision, seems present in some inquiries. Is the threat of being publicly summoned before a congressional committee if one signs a certain petition, espouses a certain view, or associates with a certain individual or group, regarded as sufficiently unpleasant to cause people to think twice before signing the petition, espousing the view, or associating with the individual or the group? Insofar as it is, it does act as a restraint. The point concerns not merely the impact on the particular witness, but the impact on an indeterminate number of other people who might be intimidated by the public example of the witness' appearance before the committee.

There are still some formidable difficulties with this segment of the argument however. First, is it the appearance before the committee that really adds this sanction or is it simply that people with unpopular views must expect some social pressure and estrangement because of them? I think that the committee device adds to the social pressure in two ways. First, it is government surveillance; it is a dramatic intrusion into the individual's life; and the prestige of governmental inquiry suggests vaguely but ineradicably that the individual is now "in trouble." Second, the committee itself has frequently colored the context strongly, so as to make it appear that somehow the view of the witness is shameful, or associated with the shameful.

There is also the question of whether freedom of speech includes the freedom of silence, of keeping one's views to one's self. Is not the whole point of free speech the public sharing of opinions? How can a man who, for example, publicly favors the pardoning of Morton Sobell, object if a committee asks him under oath whether he favors the pardoning of Sobell? But a man may be quite willing to explain his views on the Sobell case in a forum of his own choice and yet be troubled by the prospect of being summoned to Washington and asked about them in a context of inquiry into subversive activity.

In any event, the existence of such restraints has won considerable judicial recognition by now. In the *Barsky* case, which was decided a decade ago by the Court of Appeals for the District of Columbia, the free speech issue was brilliantly debated by Judges Prettyman and Edgerton, with Judge Prettyman writing for the majority in upholding a contempt citation. He recognized that some restraint on speech was involved but held that under the circumstances, it was justified. In the *Rumely* case which passed through the same court a few years later on its way to the Supreme Court, Judge Prettyman had another opportunity to discuss the matter and significantly he said:

> To publicize or to report to the Congress the names and addresses of purchasers of books, pamphlets, and periodicals is a realistic interference with the publication and sale of those writings. This is another problem which we examined in the Barsky case, and we there held that the public inquiry there involved was an infringement of free speech. We are of the same view here. There can be no doubt in that case or in this one, that the realistic effect of public embarrassment is a powerful interference with free expression of views.

Perhaps the most prestigeful and explicit statement of the restraint-point occurs in the opinion of Chief Justice Warren in the *Watkins* case where he observed:

> Abuse of the investigative process may imperceptibly lead to abridgment of protected freedoms. The mere summoning of a witness and the compelling him to testify against his will about his beliefs, expressions, or associations is a measure of governmental interference. And when those forced revelations concern matters that are unorthodox, unpopular, or even hateful to the general public, the reaction in the life of the witness may be disastrous. This effect is even more harsh when it is past beliefs, expressions, or associations that are disclosed and judged by current standards rather than those contemporary with the matter exposed. Nor does the witness alone suffer the consequences. Those who are identified by witnesses and thereby placed in the same glare of publicity are equally subject to public stigma, scorn, and obloquy. Beyond that, there is the more subtle and immeasurable effect upon those who tend to adhere to the most orthodox and uncontroversial views and associations in order to avoid a similar fate at some further time. That this impact is partly the result of nongovernmental activity by private persons cannot relieve the investigators of their responsibility for initiating the reaction.

The *Watkins* case however was not decided on First Amendment grounds but on the basis of the lack of pertinency. And in the more recent *Barenblatt* case the majority of the Court again rejected the First Amendment challenge. However, it is notable here that three Justices —Black, Douglas, and Warren—did argue in dissent that the inquiry violated the First Amendment; and Justice Brennan in his dissent in the *Uphaus* case eloquently expressed the same point.

Still more recently, in somewhat different contexts, the Court has strongly ratified the thesis that compulsory public disclosure may constitute a serious restraint on the freedom of speech. In two cases involving the NAACP the Court has held unconstitutional state efforts to compel disclosure of membership lists; and in the *Talley* case, which invalidated an ordinance requiring disclosure of the names and addresses of authors and sponsors of pamphlets, the Court gave unmistakable recognition, although not without three dissents, to the reality of the subtle restraint involved. The majority

opinion by Justice Black observed in praise of anonymity:[3]

There can be no doubt that such an identification requirement would tend to restrict freedom to distribute information and thereby freedom of expression . . . Anonymous pamphlets, leaflets, brochures, and even books have played an important role in the progress of mankind. Persecuted groups and sects from time to time throughout history have been able to criticize oppressive practices and laws either anonymously or not at all.

The First Amendment argument is not won simply by showing that there is a restraint; it still must meet the formidable question of whether the restraint is justified by the national interest. It is familiar by now that under some circumstances the State may even use direct criminal sanctions to restrain speech. The test of their propriety is the famous formula, first announced by Justice Holmes, which permits such restraints only if there is in the speech a clear and present danger of some substantive evil the State has the power to suppress. However, the issue is less easy to handle when the restraint is indirect and consequential, as in the congressional inqueries. The clearest indication of how to assess such restraints is found in the opinions of Judge Prettyman. He would permit the restraint involved in the Communist queries in the *Barsky* case because of the high government interest in the matter. He would not permit the restraint involved in the disclosure of book purchasers in the *Rumely* case because "there is no suggestion that the publication or distribution of these books and documents constitutes any public danger, clear or otherwise, present or otherwise." We thus balance the government's interest in the inquiry against the restraint generated by the inquiry; and thus far whenever the reality of the restraint has been recognized by the courts, the government's interest in the matter has been held to justify it.[4]

The Pauling Case

Given this legal framework, how does the *Pauling* case fit in? Mr. Pauling had, of course, disclosed to the Committee the names of those who had signed the petition. The Committee however was puzzled as to how Mr. Pauling had so quickly garnered so many signatures, and sought information as to how the petition was financed and as to who had helped Mr. Pauling collect the signatures. Here again Mr. Pauling testified, pointing out that much of this information had been set forth in his book No More War. Finally, however, the Committee asked to see the correspondence Mr. Pauling had received from his 1,000 or so collaborators in securing the signatures. At this point, Mr. Pauling balked, and it is this request by the committee which raises the First Amendment issue. Mr. Pauling felt that many young scientists might have relied on him in participating in the collection of names for the petition, and he did not wish to expose them to the hazards of congressional investigation. He argued that his own utility as a publicist against nuclear tests would be destroyed if he turned over the correspondence, and that the whole freedom to petition government would be cast under a cloud if those who participated could, because of that participation, be summoned before a congressional inquest to explain their actions.

One might question whether Mr. Pauling drew his line at the right point. Since he had turned over the names of those who had helped him organize, it might be argued he had surrendered the interest he was fighting to protect. However, since there were so many names, the risk of the Committee calling them all presumably was small. But if the full correspondence through which the signatures were returned to him was available to it, the Committee might single out the most productive of his helpers, or might exploit whatever might have been said in the letters of transmittal to him. While Mr. Pauling might perhaps have drawn his line at an earlier point, and declined to disclose the names of those he had asked for help, he made his stand at a significant point and fully preserved an important issue of principle.

On this basis, the Pauling case thus presents a fairly vivid example of the subtle imponderable restraint on the freedom to petition that the Committee's question would have created. It would have made it evident that to cooperate with Mr. Pauling on a petition against nuclear tests was a pretty good way to get in trouble, however imprecise and vague the trouble.

The Question of Communist Support

This, however, does less than justice to the Committee's real point, which was to see whether this sensationally successful petition effort was aided by Communist support. The Committee, although surprisingly unclear at the hearings as to what its precise objectives were, or as to just what suspicion about the petition it was investigating, might have argued that it was in the national interest to find out whether the petition had succeeded largely through Communist organizational efforts. And, although the upshot of the hearings was to show that there was no basis in fact for this supposition, would not this have been a proper thing for a congressional committee to unearth for the benefit of the public? And consequently were not the restraints of the inquiry

[3] To the roster of impressive judicial statements on the restraint involved, should be added the eloquent dissent of Judge C. Clark in the *Josephson* case, another Un-American Activities contempt case, which was decided by the Court of Appeals for the Second Circuit in 1947. The majority opinion in the *Josephson* case is also noteworthy as a clear judicial statement of the position that no real restraint is involved in inquiry of this sort.

[4] The most authoritative statement of this balancing of interests test of the First Amendment in congressional investigations is found in the opinion of Justice Harlan, writing for the majority of the Supreme Court in the *Barenblatt* case. There are also excellent statements by Justice Harlan in the *NAACP* case, and by Justice Stewart in the *Bates* case. For the present purpose, however, we find the analysis by Judge Prettyman most helpful.

justified by the national interest? Here we reach the crux of the profound policy issue the Pauling hearings present.

I would argue that the answer is that no national interest is served by the inquiry. The petition spoke for itself, and on an important public issue; and there was no suggestion that the signatures were obtained by fraud of any sort. Under these circumstances, it is immaterial who helped collect the signatures. The Communists are not invariably wrong so as to provide a certain, albeit negative, touchstone of truth on public issues. And it would be a fatal policy to permit governmental inquiry into the degree to which they have helped stimulate public opinion on any issue. We would be sanctioning the worst sort of *ad hominem* argument. We would invite the judging of the truth of what was said on public issues not by the merits of the content but simply on the basis of the auspices. We need cite only the segregation case to see where this policy might lead, for the Communists too are in favor of racial integration. To permit full-scale governmental inquiry into the sources of Communist support on public issues is to permit the Communists to poison the public discussion of any issue by the simple expedient of embracing one side of it.[5]

In my view there is, then, no national interest in finding out whether there was Communist support for the petition, since even if we find that there was, it does not tell us anything we can usefully use. If anything, the national interest lies in not raising the question.

The basic point was put definitively some years ago by the United States Supreme Court in *De Jonge* vs. *Oregon*. De Jonge had spoken at a public meeting held under the auspices of the Communist Party and was indicted for a violation of the state criminal syndicalist law which made it a crime to advocate political change by violent means. De Jonge was a Communist but his speech had discussed only such items as the longshoreman's strike and the conditions in the county jail. The Court held that the statute as applied in this case made it illegal to assist in a meeting otherwise lawful if the meeting was held under the auspices of the Communist Party. The Court was willing to asume that the Party did advocate violent change. But it held, in an unanimous opinion, that the statute as applied violated the "right of peaceful assembly" which was "a right cognate to those of free speech and free press" and "equally fundamental." The opinion of Chief Justice Hughes went on to state:

> The question if the rights of free speech and peaceable assembly are to be preserved, is not as to the auspices under which the meeting is held but as to its purpose; not as to the relations of the speakers but whether their utterances transcend the bounds of the freedom of speech which the Consitution protects.

[5] This basic issue is, as I see it, also involved in the *Braden* and *Wilkinson* cases. In both, there appears to be congressional investigation of the forces behind the segregation movement. The Court of Appeals for the Fifth Circuit, however, in upholding the contempt convictions of the two men seems to have missed the point we are arguing here.

The Pauling case shows still another facet of the free speech issue. Mr. Pauling made it very evident that he felt that turning over the names and correspondence to the Committee would place him in the role of an informer, a role he personally found distasteful in the extreme. Although several cases have involved the point, the Court has never directly passed on the question of whether a witness is constitutionally privileged not to inform on others, so long as he testifies freely about himself.

Certainly drawing a line of privacy here would correspond to the popular feeling that a man of honor does not inform, but the point has little legal substance. Does the question of informing still have some vitality in the context of the free speech isue? Does the threat that one may be placed in a position where he will be asked to inform constitute a restraint which the law can properly recognize? As a practical matter this is the more realistic threat for most people but I simply do not know whether the point is valid here. It can be argued persuasively that this is a visible and real restraint, but it can be argued also that it is an illegitimate ground for embarrassment and that the state cannot properly be charged with this consequential restraint.

The Seditious Libel Analogy

There is one final aspect of the Pauling case which now clamors for discussion. Mr. Pauling was a leading spokesman in favor of nuclear test bans. Senator Dodd was a leading spokesman for the opposite view. Senator Dodd was chairman of the Committee which called Mr. Pauling. Does this make any difference legally? Although the issue presented is again novel as a legal matter, I think Senator Dodd's role does make a difference and that it touches another theme of great importance.

The worst crime against freedom of speech is seditious libel under which criticism of government policy or officialdom can be called into question by the action of the government or of the officials involved.[6] This is really the mark of tyranny, and once this is possible, freedom in any serious sense has disappeared. Although I doubt that Senator Dodd intended to exploit his position on the Committee as a way of helping his side of the debate on nuclear tests, it has this consequence. It looks like an effort to use the governmental investigatory power to poison the public impression of the Pauling position and to impeach the force of the Pauling petition. And in this case appearances are enough. In fact it is one of the more alarming features of the case that Senator Dodd and his colleagues appear to have been so insensitive to appearances. If the state were to use its direct criminal sanctions to favor one side of the debate on nuclear tests, we would have

[6] It should not be overlooked that, strictly speaking, it was Mr. Pauling who was supporting the official government policy on nuclear tests, and Senator Dodd who was opposing it. This circumstance appears to me to strengthen the seditious libel analogy.

genuine tyranny. And if the state uses its indirect sanctions to this end, I would say that the result is much the same. I would conclude, therefore, that congressional investigatory power cannot constitutionally be used in support of one side of a public issue and that Senator Dodd's role as a participant in the debate over nuclear tests adds immeasurably to the strength of Mr. Pauling's First Amendment case.

Conclusion

The Pauling hearings thus seem to me to represent a seriously misconceived use of the congressional investigatory power. Thanks to Mr. Pauling's resolute stand the precedent they might have set is considerably less threatening today. As we have seen, the Pauling Case "that might have been" would have proved extraordinarily useful in illuminating the law on troublesome and important points. Although I feel ambivalent about the loss of so good a test case, I am delighted that the controversy between Mr. Pauling and the Committee was resolved so sensibly. Yet this resoultion is more a tribute to Mr. Pauling's stature, and the Committee's lack of appetite for testing legally the wide powers it claims, than to the good sense of the Committee. The hearings are one more memorable example of how much is still to be done by Congress and the courts if the congressional investigation is ever to become a satisfactory part of the democratic process. And we should not forget the admirable contribution that Linus Pauling, whose many contributions to science have been so widely and well recognized, has this time made to a free society.

Linus Carl Pauling—Outspoken Scientist

(Continued from page 382)

Washington. He received a call from the subcommittee to come to Capitol Hill and answer questions about the nuclear test ban petition he circulated in 1957. He explained his position at length in his easy, reasonable, often eloquent manner. The petition, signed by 11,021 scientists from 49 countries and presented to the U.N. on January 15, 1958, was initiated entirely by himself because he thought the continuation of nuclear weapons tests a bad idea. He agreed to give the committee the names of people he had written to, and the petition with its names was, of course, available. When asked for the names of the people who had helped collect the signatures, he refused. He said he knew from personal experience that giving names to a congressional committee could lead to reprisals and these people had done nothing but exercise their constitutional right to petition government. Up to this point the tone of the hearings had been fair, even genteel (said *Science*) but then came a demand that Pauling return on August 9 with the names. A delay was granted and on October 11 when Pauling was again before the subcommittee, their demand was not pushed.

The last years have seen Pauling devoting himself more and more to the fight against nuclear weapons and the continuation of the arms race. He resigned his administrative posts at Cal Tech and has made a second career of "speaking out." His book *No More War* which appeared in 1958 is an eloquent plea to stop nuclear testing because of the genetic hazards. He is in demand the world over; he has gone to a Pugwash Conference and in 1959 both he and his wife spoke at the annual conference of the Japanese Council Against A- and H-Bombs. This group certainly has the support of Communists as well as non-Communists and it is typical of Pauling not to be deterred from his goals by associates not exactly persona grata to our State Department. When he was first attacked in California he said he would continue to speak his mind and to associate with anyone he pleased.

As a speaker, Pauling is humorous, personal, and very, very self-confident. He seeks to arouse the idealism of people, especially young people, to work for ends all sane men agree with—a test ban, disarmament, peace, freedom, survival. He can make the evil he opposes seem fantastic and ludicrous so that young audiences laugh as he describes the terrible results of nuclear war. Besides being for good as against evil, for love as against hate, he is in favor of the Rapacki Plan for a nuclear free zone in central Europe and believes that we should have paid attention to the Chinese proposal for a similiar zone in the Pacific. To the more mature knowledgeable person, his oversimplifications and unqualified absolutes tend to seem irresponsible. On the question of justification for the Hiroshima and Nagasaki bombings—he sees none whatsoever—he uses hindsight to distort the realities of a nation at war.

Perhaps it is the gap between the crusader attacking large evils from the outside and the man in responsible position having to make difficult decisions that explains a certain caution with which many of Pauling's scientific colleagues regard him. The names of very few outstanding scientists "having knowledge of the dangers involved" were to be found among the 11,000 of the test ban petition. Many think that backing generalized utopian solutions makes a scientist lose his effectiveness; others feel mass petitions to be useless. Although Pauling cannot be regarded as the spokesman for the scientific community, he is a spokesman whose independence, courage, and fighting qualities are recognized by his fellow scientists.

—Helen C. Allison

Nth Countries and Disarmament

FRED CHARLES IKLÉ

THE possibility that more and more countries might acquire nuclear weapons—often referred to as the "Nth country" problem—has received a great deal of attention in discussions on disarmament. Concern has been expressed lest this diffusion of nuclear capabilities upset international stability and increase the danger of general war. As a result, many people believe that the "Nth country" problem should receive highest priority in our effort for arms control measures. Indeed, it has been argued that disarmament might turn out to be impossible unless immediate steps are taken to control this problem.[1]

The high priority assigned to controls against "Nth countries" is based, essentially, on three arguments: (1) that the diffusion of nuclear capabilities presents one of the greatest dangers, (2) that it is feasible to stop this diffusion now, and (3) that it will become increasingly more difficult or impossible to control it later. It is our thesis that each of these arguments must be qualified by a number of counterarguments, so that on balance it becomes more doubtful whether "Nth country" controls must figure so prominently in disarmament policies. But this is not to say that we should be disinterested in controlling the spread of nuclear weapons!

[1] Hugh Gaitskell, for example, said: "I view the spread of nuclear weapons to the nations of the world as a prospect fraught with the utmost danger. Unless something is done to stop it I believe that within the next ten years this problem is going to dominate the whole international situation." (Speech at Walsall, June 28, 1959.) And Senator Hubert Humphrey wrote: "If decisive action is not taken soon on agreements to control and curb the weapons of mass destruction, so many countries will possess them that control will no longer be a possibility." (*The Progressive*, October 1959.) Similarly, Hans Morgenthau stated: "If the nuclear armaments race cannot be brought under control before any number of nations will have nuclear weapons, only a miracle will save mankind." (Letter to the *Washington Post*, February 23, 1960.)

[2] National Planning Association, *The "Nth Country" Problem and Arms Control*, (1959); Arthur Lee Burns, *Power Politics and the Growing Nuclear Club* (Center of International Studies, Princeton University, 1959); Richard S. Leghorn, "The Problem of Accidental War," *Bulletin of the Atomic Scientists*, June 1958; Howard Simons, "World-Wide Capabilities for Production and Control of Nuclear Weapons," *Daedalus*, Summer 1959; and Denis Healy, "H-bombs for Everybody? The Dangers of Nuclear Plenty," *Commentary*, January 1960.

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Since the above-listed arguments have been developed cogently in a number of thoughtful writings,[2] we can, for the sake of brevity, confine ourselves mainly to the counterarguments.

The Dangers from "Nth Countries"

The most important argument that has been advanced against the diffusion of nuclear capabilities is that this diffusion would increase the probability of a global thermonuclear war. Two explanations have been offered for this argument; we might call them the "statistical theory" and the "catalytic war theory."

According to the "statistical theory" the probability of a global thermonuclear war increases as the number of nuclear powers increases, because (a) the larger the number of these powers, the greater the probability that nuclear weapons will be used in some conflict (both because of more opportunities and a greater chance of irresponsibility); and (b) if nuclear weapons are used in a conflict, the risk of its expanding into a global war is greater than if the conflict remained non-nuclear.[3]

The counterargument, which should be weighed against this proposition, is that the diffusion of nuclear capabilities might make the involvement of major powers in local conflicts appear to be more risky and hence render it less likely. In other words, "Nth country" capabilities might either help to deter local aggression altogether or they might help to isolate local conflicts. Intuitively, one would probably give more weight to the "statistical theory" than to this counterargument, but the case is not as clear-cut and well-proven as it might seem at first brush.

The second theory, the "catalytic war" theory, holds that an "Nth country" might start a global war delib-

[3] Usually, this "statistical theory" is not spelled out in detail, but advanced more as an intuitive proposition that "Nth countries" would increase the "mathematical chances of war."

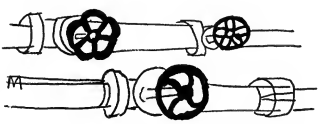
erately through the simulation of an attack by one of the major powers against the other. If the major powers maintain some elementary precautions against such an accidental triggering of a war, the technological requirements for such a strategy will be much greater than commonly assumed in this theory. However, even if an "Nth country" possessed the requisite capability (including delivery systems, intelligence information, etc.) its possible motives for "catalyzing" a global war would seem to be outweighed by overwhelming risks: (1) the instigating "Nth country" might not survive the central war, (a) because of the repercussions from world-wide fallout, (b) because it might be on the target list of one of the major powers and suffer direct attack. (2) If one of the major powers emerged as a strong winner, the instigating government would fall under its domination instead of gaining opportunities for aggrandizement. (3) The nuclear weapons might fail to trigger a central war and the instigators might subsequently be discovered and eliminated. (4) The operation might be discovered before it was accomplished, with similar results.[4]

These counterarguments both against the "statistical theory" and against the "catalytic war theory" do not deny that the diffusion of nuclear capabilities might make local nuclear disasters more likely, either in an "Nth country" conflict or as a result of irresponsible action. What they question is the notion that such local disasters would necessarily increase the risk of global war. The more critical factors that determine that risk are the reaction time, the decision-making processes, and the vulnerability of the major powers, all of which are more or less independent of "Nth countries."[5]

Can Potential "Nth Countries" Now Be Stopped?

The second argument, which we wish to examine, is that it is feasible to stop the diffusion of nuclear weapons at this time through some arms control measures. What measures have been proposed?

The one most prominently mentioned is an international agreement to stop the testing of nuclear weapons. Both those in favor of a test ban and those opposed have rarely analyzed the actual effect of such a ban on the "Nth country" problem—quite a remarkable shortcoming of this long intellectual debate! Here we only wish to examine this link; we will *not* deal with a test ban proper and the various arguments for and against it that have been raised.



The effectiveness of test suspension to curb "Nth country" capabilities is subject to four limitations:

(1) Important potential "Nth countries" might simply refuse to accede to the treaty—world opinion not withstanding. There exists no legal, or at least politically feasible, international measure by which the United Nations or any other group of powers could force a country to accede.[6] Some potential nuclear powers might try to wrest unacceptable concessions for their accession to the treaty—especially from countries where domestic political forces demand that the treaty be made universal. For example, in the British Parliament statements have been made that France must accede to the treaty, and in the U.S. Senate the importance of China's accession has often been stressed. How high a price will France or China try to exact for their signature to the treaty?

(2) Even if most countries did accede to the treaty, certain nuclear weapons could be developed without testing, and perhaps with good reliability. An "Nth country" might feel confident enough about such weapons, and it could try to convince the world by arguing that the first weapons tested by the other nuclear powers all seemed to have worked.

(3) Certain tests of small weapons might not be detectable by the international inspection mechanism, especially in a large, closed country like China. (This limitation has received a great deal of attention—perhaps excessively in relation to the other limitations.)

(4) An irresponsible country could expect that there would be no significant sanction, should its violation be detected. (The present draft treaty does not provide for any sanctions!) Would a Hitler be deterred from

[4] In spite of frequent references to the "catalytic war theory," these hurdles which the "catalyzing" country would have to pass, are rarely discussed. Arthur Lee Burns' study, The Rationale of Catalytic War (Center of International Studies, Princeton University, 1959)—its title notwithstanding—does not deal with the rationale of the "catalyzing" government or its possible irrational processes. (This does not detract from the usefulness of Burns' analysis of a situation where several, about equally strong, nuclear powers fear a surprise attack from each other.)

[5] To the extent that there is a dependence, it might well work in the other direction: the presence of "Nth countries" might stimulate the major powers to institute more cautious reaction and decision processes.

[6] It is remarkable that this fundamental limitation has scarcely been mentioned in public discussions. For example, even the very thoughtful studies of the National Planning Association make no mention of the accession problem. (*Establishing International Control of Nuclear Testing*, pp. 9 and 16, and The "Nth Country" Problem and Arms Control, pp. xvi-xvii and 33.) Leo Szilard, in his article "To Stop or Not To Stop" (Bulletin of the Atomic Scientists, March 1960), however, did point out that a potential "Nth country" might well demand bombs in return for acceding to a test ban.

breaking a treaty by the risk of an unfavorable reaction of world opinion? We must recall here, that it is precisely the irresponsible governments, not the law-abiding ones, that worry us in the "Nth country" problem.

In spite of all these limitations, however, a test ban might have some inhibiting effect on "Nth country" capabilities by slowing down international competition, so that even aggressive and irresponsible countries might move more slowly. We can hope for such an inhibiting effect, but we can't count on it.

Other possible measures to curb "Nth countries" are subject to similar limitations. The more rigorous the controls, the greater is the accession problem; the more palatable—and hence weaker—the controls, the greater the risk of evasion. The reluctance of many countries to submit to international controls is well-illustrated by India's opposition to the rather mild controls of the International Atomic Energy Agency. Effective measures against "Nth country" capabilities would have to go much further than these IAEA controls.

In theory, the two major powers in cooperation would of course have the military might to prevent any other nation from developing its nuclear weapons. It has often happened that former opponents joined forces to face a new common enemy. In the present-day reality, however, the basic conflict of interests between the United States and the Soviet Union interferes even with very mild common efforts to control "Nth countries." For one thing, the West suffers from a negotiatory weakness. The more exercised Western statesmen and public opinion become about "Nth country" dangers, the more disinterested can the Soviet negotiators pretend to be.[7] Thus, the West may pay an inordinate price to make some small progress on an ostensibly mutual problem.

Furthermore, in those areas where "Nth country" capabilities are a live issue today, the mutuality of interest is tempered by diametrically opposed political objectives. Since the Communist bloc can use military threats to exert political pressures on Western allies (for instance, the military threats used in official statements regarding Berlin and West Germany), nuclear weapons play a different role among our allies than they would, say, among Warsaw pact countries. Similarly, it would seem to be in the Western interest that nuclear assistance becomes a divisive issue between Moscow and Peking, whereas the Russians would probably like this issue to cause trouble between us and the French.

Despite all these qualifications, a case can be made for a *limited* mutuality of interest between us and the Russians in curbing the spread of nuclear capabilities. But this might express itself more effectively in tacit mutual restraint than in explicit arms control measures. For example, it would seem politically infeasible for the Russians to sign an agreement to withhold nuclear assistance from China, in return, say, for a U.S. commitment to do likewise with regards to West Germany or other allies, for this would impose unacceptable strains on Moscow's relations with Peking. But as long as we do not commit ourselves to give, or not to give, nuclear weapons to our Far Eastern allies, the Russians have a double incentive to remain cautious about giving nuclear assistance to China.

"Nth Country" Controls

The third argument which we think should be qualified maintains that the only time to control the spread of nuclear weapons is now, before more than three or four powers possess independent capabilities. It may be true that the progressive diffusion of these weapons is hard to reverse. Or to put it more precisely, it seems likely that a country which possessed nuclear weapons would demand more in return for giving up these weapons than a country that did not yet possess them. And if two countries are hostile to each other, the acquisition of nuclear weapons by one will spur the other to follow suit. But this does not mean that undesirable effects from diffused nuclear capabilities would be beyond control. In fact, it may be easier to control the possible dangers from "Nth countries" when they begin to manifest themselves, than to try to prevent the development of indigenous nuclear capabilities. Manifest dangers would stimulate the mutuality of interest among the major powers more strongly than mere potential dangers. Hence, the climate for international controls with effective sanctions could become far more favorable than it is today.

The negotiatory prospects, too, need not necessarily deteriorate. It is true that more nations would have to participate in the initial negotiations for nuclear arms controls, rather than in the subsequent negotiations concerning the accession to a finished treaty (which might be just as tough!). This would make life harder for the negotiating teams, but it need not make an agreement less likely. Would a test ban have been facilitated if only the United States and the Soviet Union had been involved? The few agreements bearing on arms control which have recently been concluded—such as the IAEA statute and the Antarctica treaty—typically involved many nations.

[7] For example, during the United Nations debate on the IAEA the Soviet representative said: "The Soviet delegation considers that the inspection and control of recipient states, that is to say the underdeveloped countries, can only infringe their sovereign rights and retard . . . peaceful atomic industry. . . . The Soviet Union concludes bilateral agreements on atomic cooperation with other countries on the basis of equality and mutual respect. . . . The agreements contain no conditions referring to control and inspection. . . ." (U.N. General Assembly, October 30, 1958.)

Similarly, on November 20, 1959, the U.N. General Assembly adopted with 70 votes the Irish resolution which recommended that the ten-nation disarmament conference study measures to curb the spread of nuclear weapons. The Soviet bloc, however, abstained (as did France).

The argument that the diffusion of nuclear weapons is irreversible is also based partly on the contention that an agreement to abolish nuclear weapons would become more difficult to control with an increasingly larger number of countries in a position to hide finished weapons. It is certainly true that we know of no method to detect hidden nuclear weapons, and that this would constitute an immense problem if the United States and the Soviet Union tried to set up an inspection scheme to make sure that neither one kept any hidden bombs. The comparatively few weapons that other countries might eventually produce would add little to this problem. Furthermore, it must be remembered that it is by no means certain that clandestine diversion of peaceful nuclear energy programs to weapons production could always be detected, although this task is more manageable than the detection of hidden bombs.

Particular concern has been expressed that irresponsible small or medium powers might create serious international problems to the disadvantage of the major powers. If none of the major powers wants to back up such an irresponsible country and become involved in its conflicts, the threat could readily be controlled with the means now available to international organizations. For example, the United Nations Security Council might be a useful organ to enforce restitution of any gain from an act of local nuclear aggression.[8] A historical precedent for such action may be found in the U.N. settlement of the British-French-Israeli attack on Egypt. The Soviet Union, of course, did not openly cooperate with the United States at that time, but in a sense it consented to the settlement sponsored by the United States and Canada. (It abstained on the vote creating the United Nations Emergency Force.)

In an area where the major powers could not agree on joint international action, the threats from a smaller nuclear power might still be controlled by regional arrangements. For example, if a Latin American country threatened a neighboring country with nuclear weapons, the United States would probably not wish to see the Soviet Union enter as "peacemaker," assuming that the American-Russian conflict would still be the dominant problem at such a time. Given some cooperation from the other hemisphere countries, however, the aggressor could be restrained, or if necessary punished, through an effort of the Organization of American States.

In these two examples we have suggested only the use of international bodies that already exist. It seems reasonable to expect that additional arrangements might be developed, or existing arrangements strengthened, if the irresponsibility or aggressiveness of *independent* nuclear powers became a serious problem, particularly after nuclear weapons had once been used irresponsibly in a local conflict without direct involvement by the major powers. It is quite likely that the possible diffusion of nuclear capabilities in various regions of the world will require a special effort by the major powers influential in these regions to prevent serious threats to peace. This development, however, need not necessarily result in a net loss for international stability.

To re-emphasize, we do not wish to imply that the possible dangers from "Nth countries" are unimportant. The present nuclear powers have good reason to discourage the proliferation of independent nuclear capabilities. One way to slow it down a little, for example, would be not to assist the spreading of reactor technology, since this technology inevitably creates local capabilities that could later be misused to manufacture nuclear bombs.[9] A reduction in this kind of assistance appears more tolerable today than it would have some years ago, since the economic urgency of nuclear power has recently become rather doubtful and the enthusiasm for it in underdeveloped countries has waned.

Progress in world peace and arms control, however, does not become impossible if nuclear weapons should spread to more countries. This is not the last chance to control this problem. On the one hand, there seem to be no politically feasible measures to stop the spread of nuclear weapons now (although it can be slowed down). On the other hand, it is not impossible to control the dangers from "Nth countries" as they arise; in fact, such controls later might be more feasible than stopping the spread of weapons technology now. Those who argue for the ease of stopping the spread now, as compared with the difficulties of controlling it later, should not forget that even if it were possible to force all non-nuclear countries into an agreement never to manufacture nuclear weapons, the future enforcement of such an agreement against violators would still depend on the cooperation of the major powers. But given this cooperation, the "Nth country" problem will not be out of control!

[8] Since only the present four nuclear powers and Nationalist China have a veto power in the Security Council, a small "Nth country" could not obstruct the U.N. machinery.

[9] The restrictions of the IAEA or of bilateral agreements cannot apply to the skills and know-how, only to the materials. And even restrictions on materials might later be violated.

American Scholars Analyze U.S. Foreign Policy

OTTO FEINSTEIN

This is the first of two articles discussing the several studies of American foreign policy, prepared at the request of the Senate Committee on Foreign Relations. Otto Feinstein is an Assistant Professor at Monteith College, Wayne University, and editor of New University Thought.

THE launching of *Sputnik* late in 1957 not only signalled the coming "missile gap," but also shattered the popular image of a noisy, boisterous, but basically inferior Russia. In the public debate that followed, education, national goals, military preparedness, and foreign policy were all put under the magnifying glass. Though few, if any, basic policy changes occurred, the information gathered at that time may shed some light on the current crises, and on the foreign policy issues to be faced by the next president.

In January 1958 the Senate Committee on Foreign Relations decided to review world conditions and the American policies relevant to them, in order to establish what "impact Soviet scientific achievement might have upon our relations with the rest of the world." The scope of the review was later expanded to "a full and complete study of U.S. foreign policy," when events such as Nixon's unfortunate trip to Latin America and the Middle Eastern crisis demonstrated that it was not only Soviet scientific achievement that was affecting our position in the world. On July 31, 1958, Senate Resolution 336 was adopted, allotting $300,000 to fifteen private research organizations and universities for a series of reports reviewing the actual world conditions and our policy toward them, and recommending changes. The reports present a harsh picture of the present world reality.

Views of Foreign Service Officers

While not one of the commissioned studies, the report made to the Senate on June 15, 1959 by a group of fifty leading Foreign Service officers[1] is an excellent introduction to the foreign policy debate, and it is interesting to compare the analyses and recommendations of the foreign policy officials with those of the academic research groups. There was widespread concern among the officials over the defensive posture of American foreign policy, and its inability to come forth with new, creative and dramatic programs. The aspects of our policy that drew the most severe criticism were our conviction of American moral superiority—the "moralistic attitude of some American policy-makers and the urge to make over the world in the American image"—and the discrepancy between our verbal approval of social change and our support of the status quo, including the most reactionary regimes. This pseudo-moral view, it was claimed, has often obfuscated reality and made it impossible to view things from the other man's point of view.

Operational criticism was also very sharp. Proliferation of staffs, endless coordination, and lack of clear-cut lines of responsibility, as well as the general treatment of the Foreign Service—ambassadorships given as political rewards, and the by-passing of ambassadors in decision-making were the most frequent complaints. The stress on making the ambassador the chief of operations in a given country, a natural request from professional diplomats, implied a severe criticism of Dulles' methods of personal diplomacy, and the influence of independent

[1] *Summary of Views of Retired Foreign Service Officers*, June 15, 1959. (S. Res. 31, 86th Congress).

agencies such as the CIA in determining policy, which is often greater than that of the officials legally responsible for it.

Many officers objected to our excessive reliance on nuclear weapons and military pacts, the composition and administration of the foreign aid program, our policy toward China, and other specific policies—yet this divergence of views is not reflected by a public debate on crucial issues. Much of their criticism has been voiced occasionally in the press, but the fact that a select group of foreign service officers should have such a basic uneasiness about our policy and its implementation should have been cause for major public discussion and concern. Unfortunately, their admonition—that the foreign policy myths that shackle our people's minds must be removed, and realities faced—did not fall on fertile ground.

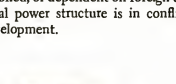
Change in Underdeveloped Countries

In this report,[2] devoted primarily to a theory of change in the underdeveloped countries, and its relation to U.S. foreign policy, we are given a new set of tools with which to examine foreign policy questions. Instead of viewing international politics as a set of power relations, the authors examine the world from the standpoint of changing socio-economic conditions. In all the reports submitted to the Senate, we find the opinion that the world is changing, and that our policy does not seem to be able to cope with these changes. But once viewed as a series of problems in social and economic change, international relations become concerned with alternative methods of permitting or facilitating this change, a method of analysis far different from the traditional one of power politics. The basic assumption of the power politics theory—the maintenance of the status quo—is challenged by the Rostow analysis (named after one of the authors of this report, W. W. Rostow). The Rostow analysis, taking change rather than the status quo as its basic assumption, would accept certain changes in the balance of power as inevitable, instead of attempting to prevent them.

The report distinguishes three categories of "underdeveloped" nations, each of which has a different series of economic, social, and political problems to face. The first category—the "traditional stage"—includes most of Africa, the Middle East, and parts of Latin America; the second, in which the nation has some "modern men," social overhead capital, and institutions of central government, includes India, Pakistan, Indonesia, Burma, Iran, and Iraq; and the third includes nations which are "committed to attempt a take-off into self-sustained growth." The major problem facing all of these countries is passing from one stage to another without major disturbance.

By intrusion—colonialism or trade—new ideas and technologies beat against the social structures of the underdeveloped countries. The spread of literacy and skills, the intensity of world communication, and population pressures add to the "powerful and persistent forces . . . pressing all the traditional societies in the direction of modernization." Lack of capital, and the political, social, and psychological resistance of the threatened elites heighten these tensions. But the stronger the pressures, the greater the liabilities of the traditional elites become.

There is also socio-political resistance to change. Structural changes in two nonindustrial sectors—public utilities and agriculture—are necessary for economic and social change and development. Yet the traditional elite's power usually rests on their ownership of land, and foreign investors often control public utilities (and, as in Cuba and Central America, the modern part of agriculture). In addition, the few capital-forming and foreign exchange earning industries that exist are either owned, controlled, or dependent on foreign capital. Thus the traditional power structure is in conflict with the needs for development.



It is extremely difficult to break the vicious circle of poverty without substantial sources of foreign exchange in the early stages. But if "take-off" does not occur, and short-run stagnation sets in, the changes which seem inevitable in the long run will be even more radical when they come. These problems present U.S. policy-makers with a series of major decisions, particularly when considered in the light of population pressure, rapid technological advance, and the cold war.

The authors of the report view the basic U.S. interests as being: the maintenance of the countries' independence; peaceful relations with their neighbors; the meeting of the aspirations of their people without totalitarian controls; the establishment of stable rules of law and evolution toward working democracy; and international cooperation in helping the development of these countries. They stress the fact that since the transformation of a society is a total process, our policies and methods of implementing them must be coordinated; and the

[2] United States Foreign Policy: No. 12, *Economic, Social, and Political Change in the Underdeveloped Countries, and Its Implications for U.S. Policy*. Center for International Studies, Massachusetts Institute of Technology, March 30, 1960. (A study prepared at the request of the Committee on Foreign Relations, United States Senate, pursuant to S. Res. 336, 85th Congress, and S. Res, 31, 86th Congress.)

secondary effects (such as those following aid which reinforces elites to the point where they can resist needed internal socioeconomic change) of our direct actions must be considered. But they go on to say:

> The task of American policy is to help existing leadership groups reach consensus on the nation's objectives and assist them in integrating their efforts and their interests, and energies of the diverse rural and urban elements in their societies, in the constructive tasks of industrialization.

This policy of direct intervention seems in contradiction with the information and theory of the report, and would lead to an involvement we cannot afford. Although it might lead to temporary stability, in the long run it would build stability on our back, with every minor shift and tension becoming a major U.S. foreign policy problem. Our intervention in the crises of more developed countries, such as Italy, France, and Japan, has not led to the solution of the serious problems facing them, which constantly reappear in more critical form. And the report itself states that "there can be no easy optimism about the consequences of American action. We must face the fact that our influence is limited."

Asia and Africa

The two regional reports on underdeveloped areas[3] show the Rostow theory in action as they analyze U.S. foreign policy in these areas. Their basic findings are damning. The report on Africa states that "the United States has never had a positive, dynamic policy for Africa," and the report on Asia echoes this criticism.

The rapid increase of independent African states and the underlying racial tensions in Nyasaland, the Rhodesias, Kenya, South-West Africa, and the Union of South Africa beg for a clearly articulated American policy. All foreign policy problems facing the United States in Africa will be based on the dynamics of new nations—first, the achievement of freedom and independence, then the consolidation of the state and the establishment of friendly relations with neighbors, followed by internal economic and social development and reconstruction. The authors of the report on Africa urge the U.S. to avoid confusing nationalism with communism, to refrain from trying to force the newly independent areas to support our side in the cold war, and to realize that Africa is basically in our camp. They also warn of the dangers of "Balkanizing" Africa, and call for economic and technical aid. It is unfortunate that the report appeared before the events in the Congo.

The report on Asia observes that there, too, the traditional fabric of society is disintegrating, and that the development of the modern state is lagging. In all the countries the problems of national unity and economic development are the keystone of stability.

[3] United States Foreign Policy: No. 4, *Africa*, Program of African Studies, Northwestern University, October 23, 1959, and No. 5, *Asia*, Conlon Associates, Ltd., November 1, 1959.

Even in India—by far the most stable country in the area—the problems facing the government are very great and the $1,000,000,000 yearly gap between exports and imports cannot be ignored by friendly nations if economic development is to take place. The most rapidly changing non-Communist society in Asia, Japan, is subjected to a detailed analysis in which difficult internal adjustments and trade problems are discussed, and serious questions are raised as to the wisdom of insisting on U.S. military bases. The report's warning of the danger of our insistence on quick military agreements with Japan and its critique of the undemocratic nature of the Rhee government were written before the Japanese demonstrations against the treaty, and the deposition of Rhee.

Of course, the major challenge to current U.S. policy is China, and the report deals with China at some length, citing the impressive results of Chinese growth and central government stability. They comment that "this is the strongest and most unified government that modern China has ever had," and regard the development of any serious internal or external threat to the regime as very unlikely. With these findings well-documented, the authors claim that the question no longer is one of whether China should be allowed to participate in the world scene, but whether it can be persuaded or forced to bear any responsibility for its participation. They suggest a gradual policy leading to the recognition of China—particularly since any really meaningful international agreements need the participation of China.

The report clearly points out the continuing social ferment and political change in Asia, and the strict limitations of the possibilities open to us. It also hammers away, indirectly, at the primacy of governmental stability and economic growth, leaving democratic institutions as desirable but often unachievable goals. The recommended policies are similar to those for other underdeveloped areas: massive, long-range, planned aid and maximum contact at all levels of society, as well as the re-examination of the role of local military forces and U.S. bases.

The USSR and Eastern Europe

The Rostow analysis, which was used in the reports on underdeveloped nations, looks for social trends which can be reinforced or aided by our actions in order to create a dynamic equilibrium. Whatever the specific problems of the various societies, the transition to industrial society, with the related problems of political stability and economic growth, is present in all, and all these societies can be (and are) analyzed from this standpoint. As we shall see later, the reports on Western Europe and on military strategy use a more traditional, power politics mode of analysis, viewing problems in terms of trying to increase the force we have available in order to achieve our ends. This report on the Soviet

Union and Eastern Europe[4] brings into focus the difference between these two approaches, both of which are used. The report states:

> The Soviet problem needs to be understood not only in its military dimensions and as a problem of political and economic penetration in various parts of the world, but also as a challenge to the way in which our society organizes the use of its human and natural resources.

The first part of the report is concerned with military concepts, and shows the power politics approach in action. We see clearly the development of military strength as an independent variable unrelated to political goals. The maintenance of military strength, and certain strategic considerations, become more important factors in determining policy than a realistic evaluation of our own interests or the internal policies of our opponents; the arms balance becomes more important than the settlement of outstanding issues.

In the sections on Soviet economic growth and internal change, however, the approach used is basically that of Rostow, and questions of the maintenance of military strength are not important. Much information crucial to foreign policy is presented in an attempt to answer the questions of what the possibilities of Soviet growth are, and what consequences this will have on our policies.

Since 1950 the sum of goods and services (GNP) in the Soviet Union has grown at the rate of 6 to 9 per cent annually, while the U.S. rate has been 3 per cent. The Soviet GNP is 45 per cent of ours now, and will be 55 per cent by 1970. Rates of industrial production are even more remarkable; if they continue, the Soviet industrial product may overtake ours by 1975 or 1980. In 1958 Russian machine tool production was equal to ours, and by 1965 it is estimated to be twice ours. Capital investment in dollar terms is equal to ours. Although consumer goods are estimated to be only one-fourth to one-third of ours, even this sector of their economy has been rising rapidly since 1953. There are 1,750,000 Soviet scientists to our 1,540,000, and the scientists in training are twice the number in training here.

The elimination of the Machine Tractor Stations, the acceptance of regional planning, decentralization, changes in pricing, and even accounting and investment practices, are increasing the rationality of the Soviet economic system. As a result of this growth, significantly large funds will be available for economic aid and military purposes by 1965. Between 1954 and 1959 Soviet aid ($2.7 billion) went to 20 countries, and 4,700 technicians were sent abroad. Our aid was 2½ times as large, and we sent 6,000 technicians; but most of their aid was concentrated in a few key countries such as Yugoslavia, India, Egypt, Syria, Afghanistan, and Indonesia.

This rapid increase in Soviet strength has been accompanied by major internal changes: "Some believe that the Soviets are evolving out of the totalitarian phase into a more social democratic system; others . . . into a 'rational-technical' society." The secret police is no longer an independent force. The legal system now emphasizes "socialist legality"—new codes and procedures have been drawn up, and certain military and "special" courts have been abolished. Incentives have shifted from coercion to consumption: peasant income is said to have doubled since 1952; wages of city workers have gone up; consumption prices have gone down; the work week has decreased; and installment buying has been introduced for appliances. Intellectual ferment and a more liberal policy toward writers and intellectuals has also developed, according to the report. Changes in the style and administration of government have made decision-making closer to home, more rapid, and less tied up in red tape. And all these changes have greatly changed the temper of life.

Similar changes can also be expected in Eastern Europe. Economic growth is certain, and a repetition of the Hungarian revolt unlikely. The report suggests, therefore, that opposition in Eastern Europe can be effective only insofar as it is included in the existing regimes, and they predict that increasing diversity and economic specialization will increase stability there. But they suggest no clear policy toward either the Soviet Union or Eastern Europe. Concrete policies are not developed out of statements such as: "In the long run, we may come to regard the Russians as our most conservative and responsible adversary, as we explore the possibilities of common interest in limiting certain aspects of the arms race," and "the nature of our relation to the people of Eastern Europe remains confused, and much of the debate has lacked real content."

The findings of the report basically contradict many of our semi-official theories on the Soviet Union and Eastern Europe, and may even throw in doubt other traditional opinions of Soviet objectives (there are still people in the U.S. who believe that we are about to "liberate" the Eastern European states, and some even expect the imminent collapse of the USSR). Unfortunately, our experts cannot suggest any new and dramatic program to cope with the changes that they describe, and their conclusions often tend to minimize the contradictions between the situation they describe objectively and the official U.S. image.

Western Europe

In this report,[5] more than any of the other area studies, we find the traditional power politics approach to international problems. The analysis of Western Europe centers around the power position of the West-

[4] United States Foreign Policy: No. 11, *USSR and Eastern Europe*, Columbia-Harvard Research Group, Columbia University, February 14, 1960.

[5] United States Foreign Policy: No. 3, *Western Europe*, Foreign Policy Research Institute, University of Pennsylvania, October 15, 1959.

ern bloc and the problems of NATO. Beginning the discussion by assuming the basic problem to be the maximizing of power, and the method for dealing with this problem to be NATO, is strikingly different from the Rostow type of analysis, which would begin by analyzing the problems inherent in the current rapidity of social and economic change, and would attempt to solve the problems facing these societies in these terms.

The authors of the report begin by stating that "The future of the free world depends on the strength and unity of the North Atlantic community of nations." The statement itself can hardly be disagreed with, but somewhere between the lines lies the idea that the first and foremost problem is NATO, not that it is one of them. Although the report does, like the other reports, point out that the world is passing through a systematic revolution, and even questions the sufficiency of the nation-state as an institution, it is still primarily concerned with the power balance in Europe and the power relationship between NATO and the United States.

Central to the recommendations of this report is the establishment of an articulate and unitary North Atlantic community, including the U.S.; but this aim is far from being achieved. Aside from the division between the Outer Seven and the Inner Six, "Atlantic unity lacks centralized leadership, coherent doctrine, and most important, mass support." The rapid rise of Western European economic power has created pressure for greater independence from the U.S. and stronger emphasis on Western European interests; and although this is mentioned in the report, there is little attempt to foresee the limits of this greater independence, or to deal with the problems arising from it.

They discuss the political alignments in Europe and within various countries in terms of the weakness of the center parties, which has led to crisis in Italy, De Gaulle in France, and Adenauer in Germany. But they see this weakening, which is a manifestation of underlying changes rather than the origin of change, primarily in reference to NATO; the underlying consequences of this shift from the center for U.S. policies are not analyzed in the report, or made evident in the facts it presents.

The currently unstable balance of terror and Soviet advances in military technology have created a major crisis in European-U.S. military strategy, although this crisis has enjoyed only peripheral debate. The authors state European hesitations quite clearly:

> It will be difficult, however, because of the proximity of military to civilian targets in Western Europe, and because of the potential spiraling effect of nuclear weapons, to implement a strategy of limited nuclear war. Nevertheless, such a strategy must be projected if NATO is to be prepared for all eventualities.

They end with the evaluation that NATO must be strong enough to force the Soviet Union either to desist from war or to face total nuclear war—which means strategic nuclear capability for Europe. Unfortunately, they do not examine the consequences of such a theory.

The report makes one general recommendation: that the overriding objective of U.S. foreign policy during the next decade should be to "strengthen the NATO military alliance and to unify the Atlantic community in both the physical and the economic field." The more specific recommendations of increasing European NATO divisions, supplying strategic weapons to our allies, continuing testing, and extending the concept of "strategic goods" into a tool of economic warfare are certainly not in line with any theory of easing the cold war. But with the power politics theory, the opponent is always an aggressor in all areas, and a desire to ease the cold war denies the basic assumptions of this theory, which operates on the basis of resolving a power struggle rather than solving social and economic problems.

The authors' analysis of major trends in Europe questions the applicability of their own recommendations. In the U.K., where conservative rule is bolstered by the acceptance of reforms, great pressure has been exerted to accommodate the Western Alliance with the Soviet Union, and even with China. There is much question about the future orientation of continental attitudes and policies under De Gaulle's and Adenauer's successors, and the political imbalance in Italy raises similar doubts as to its future policies. Yet very little is used of these facts in the analysis or recommendations of the report. What, then, is the U.S. interest? The report contributes little to a clarification of this question, particularly in its recommendations.

Conclusion

Not only do these reports present a wealth of information, but they also illustrate two ways of approaching the problems of different nations. Two very different policies result from these approaches. One, being concerned with power, and maintenance of the status quo, has a serious bias toward military alliances and weapons as the means of resolving international differences. The other, more concerned with resolving problems of social and economic change, favors means of establishing a dynamic equilibrium, thereby accepting certain changes as inevitable, and favoring peaceful accommodation rather than military conflict.

However, one of the main problems in all the reports, even those using the Rostow method of analysis, is their unwillingness to draw uncomfortable conclusions from the body of their own findings. Instead we have recommendations for "more aid" and "diplomacy in depth"—or in some cases even undisputed acceptance of present policies. It is unfortunate that the defensive position decried in the body of these reports, and in the report of the foreign service officers, nearly always crops up in the conclusions and recommendations.

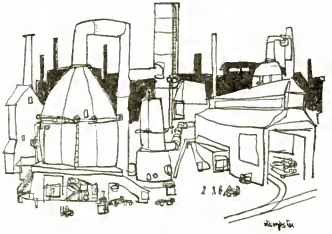
Longer Range View of Nuclear Energy

A. M. WEINBERG and E. P. WIGNER

Alvin M. Weinberg is the Director of Oak Ridge National Laboratory. Eugene P. Wigner, who headed the scientific team that designed the first nuclear reactor, is now professor of mathematical physics at the Palmer Physical Laboratory, Princeton University. Both Dr. Weinberg and Dr. Wigner recently received the Ford Motor Company's "Atoms for Peace" award in a presentation at the National Academy of Sciences.

IT MAY be startling to realize that only about 3 per cent of the U.S. national income is spent to furnish the energy we use. From this, it is evident that no golden age can be created by reducing this expenditure —not even by reducing it to nothing.

On the other hand, a substantial increase in the effort now necessary to provide our energy requirements might be a serious calamity. Thus, the true objective of reactor research may well be the preservation of our present iron age. This point underlies the following discussion[1] of whether reactor research ought to have as its primary aim the development of "burners" or of "breeders."



Breeders and Burners

Natural uranium contains only 0.7 per cent of the fissionable isotope U-235. In "burners" (burner reactors) only this 0.7 per cent of the total energy content of the uranium is utilized, and even this fraction cannot be utilized completely. "Converter" reactors are somewhat more efficient; in their present-day embodiments, they produce enough plutonium to permit, in principle, the doubling of the energy content of the U-235.

Breeder reactors, on the other hand, can convert virtually all of U-238 into fissionable plutonium, producing about 140 times more energy than burners, and 70 times more than low-conversion ratio reactors.

The breeder vs. burner argument, therfore, revolves around the question: How necessary is it to utilize the bulk of the energy content of uranium and thorium, and to what extent can we be satisfied with the utilization of a small fraction of this energy content. Throughout this article we will assume that the future energy economy will be based on fission, i.e., on the energy content of uranium and/or thorium. The discussion will also be based on the supply and consumption as they can be expected to develop in the United States. The conditions in most other parts of the world will probably become quite comparable to those in this country. Hence, it appears justifiable to base our conclusions on the conditions which we know best.

On the basis of these assumptions, the problem of breeder vs. burner reduces to the question of the supply of uranium (and thorium) available, vs. future energy requirements.

Supply and Demand of Uranium

The amount of uranium available, in the form of uranium oxide (U_3O_8), depends on the price one is willing to pay to obtain it. Thus, the cost of the energy obtained, whether from a burner, a converter, or a breeder, may depend on the cost of the uranium. This is shown in Table 1. The figures of this Table are,

[1] See also E. P. Wigner, *Acts Physical Austriaca 11*, 410 (1958).

of course, only estimates. This applies particularly to the magnitude of the supplies of more highly priced material, which should actually be tripled if breeders come into general use, because of the increased usability of thorium.

It may be mentioned at this point that the total coal reserves of the United States[2] amount to about 2×10^{12} tons, with an energy content of 50×10^{18} BTU. At present, about one-third of all the energy produced in the United States is derived from coal. The price of bituminous coal is about $4.50 per ton, giving a price of about 17¢ per 10^6 BTU. Even though used at present to a similar extent, the total energy content of the oil and gas supplies is much lower than that of coal. Furthermore, about one-half of the total coal reserves can be obtained only at more than twice the present cost. Hence, if only fuel costing less than twice the present price is considered to be available, the total fossil fuel of the U.S. amounts to 25×10^{18} BTU.

On the basis of Table 1, breeding appears to have an enormous advantage over burning. It must be remembered, however, that the price of the fuel is only one of the cost items of a reactor (around 20 per cent) and it is believed that, as a rule, the capital cost of a breeder may be higher than that of a burner. The present tendency to build burners clearly shows that it is at least easier to build a burner than a breeder. Finally, beyond a certain point, the reduction of the price of the fuel influences the cost of power very little.

Similarly, the need for energy has its limits and the availability of further energy in the form of fuel is, beyond a certain point, more of academic than of real interest.[3] On the other hand, the fact that the energy content of low-price uranium, used in a low-conversion reactor, is only a small fraction of the energy content of fossil fuels, appears most significant. This will become evident when the power requirements are discussed.

Future Power Requirements

The magnitude of the energy requirements will not be based on the production of electrical power for two reasons. First, the electrical power produced in the U.S. is less than 6 per cent of our total energy consumption. Even after making generous allowance for the relatively low thermal efficiency of the production of electrical power, it is clear that it accounts for only a fraction of our energy requirements. Second, the energy requirements increase only slowly, whereas the increase in the production of electrical energy is relatively fast. The former slow increase can be expected to remain more nearly steady over extended periods of time. It may be worth noting, however, that the conclusions to be arrived at would be modified only little if the calculation were based on the electrical power production. In fact, at least for the more distant future, the calculation used here gives lower energy requirements.

The total energy consumption in the United States was 40×10^{15} BTU in 1955, and the consumption appears to double in a little less than 25 years.[4] Table 2 gives the total consumption in 10^{18} BTU estimated, on the basis of the permanence of this increase, up to the year 2080, when it will be about thirty times the 1955 level.

TABLE 1

Cost in $/lb.	10^6 tons U_3O_8	Cost in cents/10^6 BTU			Energy content in 10^{18} BTU		
		only U^{235}	low conv.	breeding	only U^{235}	low conv.	breeding
10	0.9	5.5	2.7	0.039	0.39	0.78	56
20	3.5	11	5.5	0.077	1.35	2.7	190
30	8	16.5	8.2	0.12	3.5	7	500
50	30	27	13.5	0.19	13	26	1850
100	80	55	27	0.39	35	70	5000

The second column gives the amount of U_3O_8 that is available at the price given in the first column. The data are based on An Analysis of the Current and Long-Term Availability of Uranium and Thorium Raw Materials, TID-8201, Technical Information Service, Atomic Energy Commission, and on Sornein's estimate (article in The Industrial Challenge of Nuclear Energy, Office of European Economic Cooperation, June 1957) according to which the available amounts of uranium are roughly proportional to the square of the price one is willing to pay. This assumption is consistent with the data of the Technical Information Service. Furthermore, the numbers of Table 1 are very nearly equal to those given in a recent study by C. S. Starr and R. A. Laubenstein (The Availability of Uranium for a Nuclear Power Industry, Report A1-4945, Atomics International, 1960).

The cost of the fuel per unit amount of energy depends on the fraction of the fuel that is used. Hence, the price of the fuel in cents per million BTU, given in columns three, four and five, is different for the three types of reactors considered. Column three refers to a pure burner, column four to a reactor with conversion ratio 0.5, column five to a breeder. The figures are somewhat optimistic because no fuel can be used completely. The last three columns give the total energy obtainable in the types of reactors just enumerated. The unit of energy is 10^{18} BTU (1 BTU = 0.252 kcal = 1,055 Joules).

TABLE 2

Year	1980	2005	2030	2055	2080	
Cumulative consumption	1.6	4.7	11	23	48	$\times 10^{18}$ BTU

The objection may be raised that it is very dangerous to make any forecast for the distant future, and this objection is quite justified. Nevertheless, the figures of Table 2 seem to be the most reasonable ones—one may even expect them to be underestimates.[5] They show,

[2] See, for instance, Statistical Abstract of the U.S., 1957, Government Printing Office, Washington, D.C., pages 733 and 730; Also Sam H. Schurr's statement before congressional subcommittee, Reprint 14, Resources for the Future, Inc., Washington, 1959.

[3] See, however, Alvin M. Weinberg, Physics Today, 12 (1959), 18.

[4] Reference 2, page 526; also Sam H. Schurr, loc cit.

first, that the supply of fossil fuels (around 25×10^{18} BTU) should last for not more than 100 years. Serious local shortages are bound to develop much before. Second, they show that by the time there will be a real need for a substitute for the fossil fuels, low-conversion reactors would consume all the uranium supply of the country in about 25 years, as long as one does not wish to pay a higher price for the energy contained in uranium than one now pays for the energy contained in coal (line before last of Table 1). Hence, low-conversion-ratio reactors would provide only a stopgap for a short period when an urgent need for a new energy source will arise.[6]

On the contrary, the energy supply can be expected to be ample for many hundreds of years if uranium and thorium are used in a breeding cycle. The reason for this is not only that a pound of these materials gives about 70 times more energy if used in the breeding cycle; even more important is the fact that the exploitation of the ample supply of low concentration ores becomes possible without an increase in the price of the energy content of the fuel above the present price. As Table 1 shows, the cost of a certain amount of energy in the form of uranium remains about 140 times lower if this uranium is used in a breeding cycle, that is completely, than if only the skim of it—the U-235—is used. The ratio is 70 against a low-conversion reactor. As a result, according to Sornein's rule, the amount obtainable at a given price is $140^2 = 20{,}000$ times greater than for burners, and $70^2 = 5{,}000$ times greater than for low-conversion-ratio converters. It is this disparity between both price and availability of energy, through the use of burners and of low-conversion reactors on the one hand, and breeders on the other, which induces so many students of these questions to emphasize the advantages of the breeders over the burners.

Why Develop Nuclear Power?

In view of the sufficiency of the fossil fuels for about 100 more years, one may doubt the present need for the development of any new source of energy. It should be pointed out, however, that the situation may be rather worse than indicated, principally because fossil fuels are needed for many purposes other than energy production—for instance, for the reduction of iron ores. Hence, it would be irresponsible to exhaust the supply of fossil fuels to a very large extent. We must not forget that what we are after is the preservation of our iron age. This point has been brought out with particular clarity by G. Young; he even proposes the name "fossil organics" for coal, oil, and perhaps also for natural gas. As a result of these circumstances, the need for new energy sources may appear earlier than in a hundred years, even if the relatively low estimates of the energy requirements given in Table 2 should prove to be valid.

Second, the rapidity of our progress in science should not blind us to the fact that far-reaching changes in our methods of production continue to take a long time. Power plants, in particular, have a useful life of about 50 years, so that the conversion to nuclear economy will surely extend over a long period of time. It should not be forgotten, either, that all present thinking is directed toward replacing fossil fuels by fission energy in the electrical power industry; the problem of the replacement of fossil fuels for other purposes is still essentially untouched. As mentioned before, at present only a relatively small, though increasing, fraction of our energy is used for the generation of electricity.

Third, the transition to nuclear economy will be possible only if vast amounts of fissionable material will be available when needed. Some such fissionable material will come from isotope separation plants. However, the large inventories necessary for the huge nuclear fueled power industry of the future can be conveniently obtained only from breeders which produce fissionable material well ahead of the time when these materials will be needed for power production. In fact, several generations of breeders fueled by materials produced by earlier breeders will be necessary to produce the inventories for the critical period.

Need for Burners

There is, finally, a fourth and perhaps most important factor which renders a deliberate approach toward the use of fission energy imperative: the attendant production of vast amounts of radioactive materials. The storage and disposal of these materials will present many problems, the solution of which will have to be based on protracted practical experience. Not many mistakes can be allowed while the proposed solutions are tried out. If there were no other reasons for developing some nuclear power fast, the difficulty and urgency of the problem of the disposal of radioactive wastes would be an adequate reason.

There are, however, several other important reasons for producing nuclear power on a reasonable scale in the near future, and it is hoped that the present analysis will not be interpreted as a blanket rejection of the development and use of burners. Three of these reasons are most cogent from our point of view:

(*a*) As has been emphasized it is quite uncertain whether the problems of the breeder will be solved by a frontal assault, or by successive improvements on burners.

(*b*) Nuclear power, even before it becomes economical on a large scale, will have many specialized applications in which it may be not only economical but al-

[5] The picture presented in Palmer C. Putnam's book, *Energy in the Future* (Van Nostrand & Co., New York, 1953) is much more pessimistic.

[6] This conclusion remains valid under the assumptions made in Palmer C. Putnam's book (reference 5).

most irreplaceable. The Army Package Power Reactor may not fall into this latter category, but the nuclear batteries for rockets may. Once low-weight high-capacity batteries are easily available, many uses will be found for them.

(c) Burners will make it possible to tackle the waste disposal problem at an early date.

Conclusions

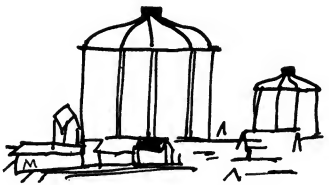
The preceding analysis suggests first, more emphasis on the search for a practical breeder; second, more emphasis on the improvement of the conversion ratio of burners; and third, more emphasis on solving the long-term waste disposal problem. As of today, nuclear energy for large power stations is uneconomical. Hence, it makes little difference whether it is very uneconomical. The large-scale use of money and of scientific manpower for the development of nuclear energy cannot be justified on the basis that it leads only to a small economical disadvantage. It can be justified only if it is directed toward the use of nuclear energy when it will be needed, and if the use of nuclear energy will indeed satisfy the need which will arise. This will be true only if breeders will be available. Short-term economic advantages, or rather, diminution of the disadvantages, are, in this connection, largely irrelevant.

Central Station Nuclear Reactors

BERNARD I. SPINRAD

NUCLEAR reactors produce energy by burning nuclear fuel—uranium, plutonium, and certain higher elements—in a controlled, self-sustaining, chain reaction. The reactors which have received the most public attention are those intended for the generation of central station power. Since it is unlikely that the cost of the nuclear reactors themselves would be less than the cost of fossil fuel furnaces, industry's main incentive for using nuclear reactors to produce energy is that the cost of nuclear fuel can be lower than that of fossil fuel. Nuclear fuel burnup costs run between .7 and 2.1 mills/kw-hr, a price well below fossil fuel costs in most parts of the United States (3 to 3.5 mills/kw-hr); and, in addition, some fissionable material can be created by the conversion of fertile U-238 into fissionable Pu-239.

A number of techniques can be used to translate these low intrinsic fuel costs into economic operating costs for a nuclear fuel cycle: first, the use of as low enrichment fuel as possible; second, the resale of as much by-product radioisotope (including new fuel isotope) as can be made; third, the reduction in cost of processes, both chemical and metallurgical, by which fuel is refabricated and reconstituted after having once been in a reactor; fourth, the elimination of the requirement for



reprocessing and refabrication to as large a degree as possible, by using the fuel for as long a period as possible; and fifth, having the fuel operate at as high a rating as is possible—owing to the fact that a critical mass of uranium fuel, which has considerable value, must be rented or considered as an investment. A properly designed nuclear system attempts to combine these fuel criteria (which are not generally mutually compatible), with a system of as low capital cost as possible. Reactor design is a continual series of compromises.

Proton-Cooled Reactors

Reactors moderated by ordinary hydrogen tend to be the most compact systems. In addition, water as a coolant has the remarkable property of having the highest heat capacity and heat removal capability of any known material. Finally, water is the working fluid of most of

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our turbo-electric generating capacity, and is the primary working fluid for many of our process heat requirements as well. Therefore, ordinary water, which is quite inexpensive, is a desirable reactor moderator and coolant.

Its major drawback is that at the high pressures and temperatures desirable for electrical generation, water is a corrosive fluid, and the primary reactor system must bear the full burden of the chemical and mechanical problems associated with its use. Therefore, there is also interest in mocking up the nuclear properties of water with organic substances of equal neutron moderating ability, capable of operating at low pressure and high temperature. Thus, water-cooled reactors and organic reactors form a single class, differing primarily in their chemistry.

Water may be boiled in the reactor, with the steam used directly in the turbine cycle; or the heat taken up in the primary coolant may be exchanged to raise secondary steam for the turbine. The apparent complexity of this indirect cycle is not necessarily uneconomical, since it leads to some improvement in neutronic efficiency, and separates such problems as load following and moisture separation from the primary reactor system.

The organic cooled and moderated reactors really fall in the category of indirect cycle reactors. Since organic fluids in the radioactive environment of a reactor are subject to radiolysis, which causes a steady attrition of the coolant and moderator fluid, the organic reactor must have an auxiliary organic cleanup system and a definite requirement for extra coolant feed material.

Uranium metal at high temperatures and pressures is appreciably reactive with water—in fact, under some circumstances, violently so. In addition, uranium metal cannot withstand long irradiation at high temperatures because the fission products build up in the metal, occupy volume, and place internal stresses on the relatively weak metal, causing it to swell. It has been determined that the use of uranium oxide obviates both of these difficulties to a great extent.

Unfortunately, both the manufacture and the reprocessing of the ceramic fuels are appreciably more expensive than that of the uranium metal, and the enrichment requirements on ceramic fuels are higher. For this reason, fuel economy may only be achieved by burning oxide fuel for a very long period of time before reprocessing and reloading is necessary, which also limits the possibility of high by-product resale.

It is possible to use uranium metal fuel in organic cooled and moderated reactors, but this can be done only at the expense of operating the reactor at coolant temperature somewhat below its maximum capability; otherwise, swelling will set in.

At the moment, no hard and fast choice can be made between the alternatives listed on the basis of their economy and operability. Many water reactors of various types are being used, and they are the cheapest nuclear power plants at present. This is not surprising, since virtually all of their technology is adaptable from technology developed in the course of developing the steam power industry. Nevertheless, extrapolations of current designs lead to very little if any advantage over fossil fuel generating plants, unless increased costs of fossil fuel are considered.

It would therefore appear that while water cooled and moderated reactors are the best that the world has to offer today, they are likely to be accepted industrially only for reasons which are akin to insurance: that is, if our present predictions of the stability of the price of fossil fuel are subject to some error, then it is desirable to have some fraction of our generating capacity in slightly more expensive nuclear capacity under a well-developed technology.

Heavy Water Reactors

Historically, heavy water was the first material to be proposed as a moderator for nuclear reactors. Its properties as a moderator make it by far the best material to use if efficiency of the nuclear chain reaction is to be the only criterion for successful reactor design. However, it has two major drawbacks compared with ordinary water. First, it is properly used in reactor lattices which contain a relatively high ratio of moderator to fuel. In consequence, heavy water systems containing a given amount of fuel must be appreciably larger in size than the equivalent light water systems, which means that many component sizes also increase. (In partial compensation, the reactor designed is much less limited in spatial arrangements within the reactor core.)

The second disadvantage is the cost of heavy water ($20 to $30 per pound), which makes it necessary for all components to be extremely leak-tight, and complicates such processes as fuel addition and removal. In view of this, heavy water is a promising moderator only when capital charges are low. In the United States, where capital charges are high, it will probably always be an appreciably more expensive material to use than light water.

The schedule of charges levied by the AEC against inventories of heavy water and enriched uranium also works against heavy water in this country. The AEC currently charges 4 per cent "rent" on enriched uranium stockpiles and critical loadings, and 12 per cent on heavy water inventories. Since the main virtue of heavy water is to allow reactor operation at no or low enrichment, this policy encourages the use of enriched uranium in preference to the use of heavy water.

Superheating

Nuclear fuel should be capable of delivering power at higher temperatures than are achievable in flames, since it has no chemical reaction products whose heat capacities limit temperature. Consequently, there is consider-

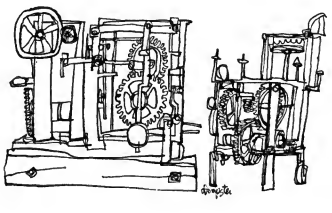
able incentive, philosophically as well as practically, to achieve higher temperatures in nuclear systems. For central station units in which steam is the working cycle, the appropriate way of achieving this goal is by superheating.

In boiling reactors it is possible to pass the saturated steam produced in a first pass of coolant through the reactor through another zone of the reactor, which is steam-cooled. The only drawback is that steam at high temperatures is a very corrosive fluid; consequently, a steam-cooled zone demands fuel elements which are encased in stainless steel or a similar material. None of the materials available today is mechanically and chemically sound and, at the same time, low in neutron absorption. The result is that superheating is achieved at the expense of nuclear efficiency; but considering the fact that heat added as superheat has a value perhaps double or triple that of heat added under saturation conditions, the nuclear investment in superheat has about a 50–50 chance of being worthwhile. Boiling reactors are now being adapted for experimental superheat operation with every probability that technical success will be demonstrated. It is interesting to note that even with advanced design, the best water-moderated reactors are not expected to become competitive with fossil fuels unless nuclear superheating proves economical.

Another way of providing superheat is by use of a separate, steam-cooled reactor in a multi-reactor complex. No such system has been proposed for construction and demonstration: however, in view of the large investment already existing in reactors which produce saturated, low-temperature steam, if there is any future at all to superheating itself there must also be an appreciable market for separate superheating reactors.

Gas-Cooled Reactors

The primary effort in both Great Britain and France has been devoted to gas-cooled reactors and this has caused considerable criticism of the United States' program, which has not given them high priority. Gas cooling is attractive in place of water cooling because the preferred gas coolants, helium and carbon dioxide, are appreciably less corrosive at high temperatures than is water at low temperature; and carbon dioxide, at least, is quite inexpensive. Moreover, these gases have little neutron capture, and therefore allow low enrichment reactor fueling.



However, gases cannot remove as much heat from a given volume as liquids can without unreasonably high exit temperatures. Helium, almost as expensive and more difficult to contain than heavy water, can remove about one-third as much heat from practical systems, but is completely inert chemically (although at high temperatures, trace impurities may cause considerable chemical attack). Carbon dioxide can remove still less heat, is quite inexpensive, and is moderately corrosive at high temperatures.

The British and French gas-cooled reactors emphasize carbon dioxide coolant due to its low cost, and because helium is a United States monopoly. The U.S. gas-cooled reactor program emphasizes helium coolant for its lack of corrosion, and also because it is a U.S. monopoly.

The use of gas cooling requires fuel elements that run at high temperatures and for this purpose uranium dioxide seems feasible. However, at high temperatures few materials have, simultaneously, the strength to support the UO_2, which tends to crack internally, and low parasitic neutron absorption.

Since the fuel, which is the most sensitive reactor component, must be at very high temperatures, there is little point to keeping the rest of the reactor cool. Graphite is a material which is an excellent neutron moderator and improves in structural performance as its temperature is increased; and is therefore the logical structural and moderator material. Reactor lattices made out of graphite have a relatively low concentration of uranium in them. Consequently, a standard heterogeneous reactor arrangement, modified for gas cooling, is a very bulky system per unit power. One possible improvement is to approach a homogeneous solid in which the fuel is dispersed uniformly in a graphite matrix element. This might introduce as many problems as it solves, but the system would be technically more elegant and seems to have more possibility for cost improvement than the standard lattice as developed abroad.

At present, the system bulk and consequent high capital cost of gas-cooled reactors makes them unpromising economically for this country. Indeed, they are not necessarily economically advantageous compared with heavy water reactors even when capital charges are considerably less.

Sodium-Cooled Thermal Reactors

The favorite approach in the United States to achieve high temperature process fluid is to use liquid metals for heat transport. Sodium metal is inexpensive, has excellent heat removal capabilities, moderately low neutron absorption, and has little effect on a variety

of other metals when pure. Sodium has been proposed as a coolant in reactors moderated by graphite and by heavy water, but owing to the violent chemical reaction existing between sodium and water, prudence has dictated the construction of the sodium-cooled graphite reactor as the experimental unit.

For the same fuel temperature conditions, sodium coolant can achieve appreciably higher temperatures than a gas coolant; alternately, for the same coolant temperature appreciably more heat can be transferred from a given fuel element to sodium than to gas. These advantages have spurred the development of sodium technology, and there is now every reason to suppose that sodium can be contained and handled without unusual expense. Sodium can be used as a heat exchange fluid to boil and superheat steam under the most modern conditions. Consequently, sodium-cooled graphite moderated thermal reactors offer an attractive possibility as long-range competitors to the water systems.

However, no nuclear fuel has been developed which can utilize the potential of sodium as a thermal reactor coolant. Uranium metal cannot stand the high temperatures of which sodium is capable without appreciable swelling, and this swelling can only be counteracted by introducing thick, neutron-absorbing restraining cladding (the jacket or can placed around a nuclear fuel element). Uranium dioxide, which does not swell, delivers so little heat per unit fuel that the heat removal potential of sodium is not used. Uranium carbide has the radiation resistance of oxide and the thermal properties of metal. It would be the natural fuel material to use with sodium coolant, but its development may be economically unsuccessful; if so, thermal reactors cooled with sodium can probably be written off.

Fast Reactors

All the reactors described have been thermal. However, a completely different reactor type, containing no moderator and capable of going critical on neutrons whose energies are only slightly less than when they are born in fission, is possible. These systems are called fast reactors and consist of tightly packed arrays of fuel with coolant passages traversing. Their neutron economy allows a large number of excess neutrons to be available for isotope production, and for this reason, they are often conceived of as breeders—i.e., systems which convert fertile isotopes into fissionable ones faster than they consume fissionable material.

Fast reactors must have high enrichments and high concentrations of fuel in their cores. Consequently, they demand very high heat removal capabilities of their coolant if the fuel is to be efficiently utilized. Thus, sodium has the same advantages as a coolant in a fast reactor as in a thermal one. Fast reactors can tolerate rather large quantities of structural material without being severely limited in performance, so heavy cladding, which is intolerable on metallic fuel in thermal sodium-cooled reactors, can be employed to advantage to restrain metal swelling in fast reactors.

The concentrated nature of fast reactor fuel makes it absolutely essential that its re-processing and re-constitution be accomplished without long time delays and with very minor losses. Pyrochemical processes and remote fabrication techniques to achieve these ends now form a large part of the fast reactor program.

Plutonium happens to have the best nuclear properties of the various fast reactor fuels. For this reason, a major effort to fabricate plutonium fuel elements is part of the fast reactor development program. Since plutonium, particularly if highly irradiated, is a hazardous material to work with, this fabrication must be done remotely, and therefore expensively. Although fast reactors are not promising as economical systems in the near future, the fact that they are now technically feasible and have good breeding capabilities makes it almost certain that ultimately they will be the mainstay of the nuclear power industry.

Aqueous Homogeneous Reactors

The highest possible density of power per unit of mass of fissionable material is achieved when fuel is uniformly dispersed in the transfer medium. The most thoroughly explored reactor of this type, and the one whose development is most advanced, is the aqueous homogeneous reactor. This reactor may be considered as a solution of uranyl sulphate in dilute sulphuric acid. This solution is contained in a primary reactor system whose major component is a pot which forms the reactor core. The solution is pumped through the pot, in which a critical volume allows the reaction to occur, and exits through a pipe of such a diameter that the critical reaction is suppressed; then its heat is removed by a heat exchanger and circulated back through the core.

The only limitations on power density of this system are the limits on the ability of the vessel and piping materials to withstand temperature, mechanical stress, and corrosion, and the limits on pumping speeds. Power densities of several hundreds of thermal kilowatts per liter of core appear practical. Although the secondary steam is of the same low quality as with other pressurized water reactors, separate superheating may obviate this disadvantage.

In principle, the fuel cycle for an aqueous solution is the simplest possible, since the fuel material is the direct product of a standard fuel process. However, solubilities of uranium compounds are low enough so that the solvent must be heavy water, rather than light, for decent neutron economy; and the fuel must be highly enriched, which adds appreciably to the expense of the process. It necessitates a large net leakage of neutrons, which must be efficiently converted if the comparatively high burnup charges on highly enriched fuel are to be avoided.

This conversion is accomplished by surrounding the core with a blanket of fertile material. Thorium is preferred because its neutron capture leads to U-233, which may be fed back into the core as fuel.

The use of U-233 as a reactor fuel carries with it the possibility of such good neutron economy that this reactor type is, in principle, capable of thermal breeding. Although minimum power costs are now associated with fuel cycles which fail to breed, these minimum costs are high enough so that the development program is long range and favors breeding. It is, to this degree, competitive with the fast reactors, compared to which it has more favorable short-term economics, but less ultimate potential.

Other Power Reactor Concepts

Since the predicted economic advantage of the best systems we have, the water reactors, is at best a marginal improvement over fossil fuel systems, there is a strong incentive to continue the search for a still better type. Some of the more attractive ones are described below.

Two high temperature homogeneous reactors use, respectively, liquid bismuth and fused fluorides as solvents. Problems of container materials, fuel addition and removal, reprocessing, maintenance, and heat exchange are severe in both cases, but technical solutions to these problems exist. It remains to be demonstrated whether these solutions allow economic power generation; this possibility is enhanced by the high system temperature, and thus, the high thermodynamic efficiency of the power cycle.

Slurries—suspensions—of uranium and thorium oxide in water and heavy water are being considered as fuel materials for a homogeneous reactor whose fuel is suspended rather than dissolved. These slurries can be circulated by natural convection and heat, extracted either by allowing the water to boil or by using a heat exchange system. Slurries are also being considered for the other homogeneous concepts. In all cases, use of a slurry allows internal conversion in a core, obviating problems caused by a separate breeder or converter blanket. Container problems are eased, but the difficulties of maintaining a uniform suspension are severe.

By introducing pellets of metal-clad uranium or uranium oxide into a vessel, and circulating a swiftly flowing stream of water upwards through them, a fluid bed will be formed whose geometry is more or less stable and is controlled by the water velocity. The reactor is thus a heterogeneous reactor with a very simple fuel element. The major problem of this type of system is to get enough power out of the water flowing through the bed while at the same time retaining the bed principle.

Rather than have the fuel material fluidized in pellets or slurried, another possibilty is to have fuel material in a static bed. The concept of this sort which has received the most study is that of a homogeneous graphite reactor fueled with uranium dispersed in the graphite. The graphite is manufactured in the form of balls or pebbles. The uranium to graphite ratio is adjusted so that the pebbles contain sufficient moderator, and high pressure gas is forced through the interstices of the packed bed. There is no reason to suppose that ultimately gas-cooled graphite reactors with a radioactive coolant will not be tractable; but certainly for any short-range technology it would be an enormous advantage to keep the fission products in the heterogeneous fuel.

Since light and heavy water have almost complementary advantages and disadvantages, there may be homogeneous and heterogeneous systems such that a mixture of light and heavy water will afford the best total system economy. One would hope to utilize the excellent slowing-down properties of water to achieve

TABLE 1

NUCLEAR POWER GENERATION COST, MILLS/KW-HR

REACTOR TYPE	FIXED CHARGES		FUEL CYCLE COST		OPERATION AND MAINTENANCE		NUCLEAR INSURANCE		TOTAL		CONSTRUCTION COMPLETION DATE
	Current	Potential	Current	Potential	Current	Potential	Current	Potential	Current	Potential	
Pressurized water	5.05	4.40	3.38	2.56	0.59	0.59	0.26	0.25	9.28	7.80	4/66
Boiling water	5.26	4.31	3.47	2.29	.61	.61	.27	.24	9.61	7.45	6/67
Light water moderated super-heat	.....	3.91	.....	1.96	.....	.61	.....	.23	.....	6.71	6/67
Organic cooled	4.39	3.53	5.72	1.83	1.09	1.09	.25	.22	11.45	6.67	1/67
Sodium graphite	6.11	4.47	4.12	2.00	.70	.65	.29	.25	11.22	7.42	1/67
Gas-cooled (enriched fuel)	5.97	4.63	3.21	2.62	.89	.49	.29	.24	10.36	7.98	1/68
Fast breeder	5.10	4.43	7.10	1.99	.79	.79	.26	.25	13.25	7.46	12/68
Aqueous homogeneous	.....	6.38	.....	2.12	.....	2.53	.....	.90	.....	11.93	1/69
Heavy water	7.03	5.80	4.22	1.21	.91	.91	.32	.28	12.50	8.29	1/70
Gas-cooled (natural uranium)	7.60	.....	3.35	.....	.61	.....	.33	.....	11.89	.....	1/68
Coal-fired plants:											
35¢/10⁶ Btu fuel cost	3.31	.....	3.32	.....	.36	.....	.....	.....	7.0	.....	.....
35¢/10⁶ Btu fuel cost	3.31	.....	2.37	.....	.36	.....	.....	.....	6.0	.....	.....

NOTE: All plants are based on 300 MWe size—80% capacity factor—14% fixed charges.

The power costs are based on the equilibrium fuel cycle which will be 3 to 4 years after completion of construction.

a reasonable compactness of the core without the extreme compactness which makes the designers' jobs difficult for the all-water case; one would hope to use the heavy water in part because its addition would lower the enrichment required for the fuel cycle; and, finally, one would hope to use the ability to vary concentrations of light and heavy water to effect reactor control.

Summary, Conclusions, and Opinions

The major development efforts in this country over the past decade have concentrated on achieving economies in the cost of capital equipment required to support the nuclear chain reaction. During this time the importance of the fuel cycle as the intrinsic raison d'etre has been lost. Table 1 is instructive in this regard. There is not a single one of the reactor types mentioned whose fixed capital charges and operating costs, even on an extrapolated potential, approach similar charges for coal-fired plants. The fuel cycle costs, even those listed as current, are on the optimistic side, since no experience exists in the U.S. in the operation of gas-cooled uranium reactors whose fuel cycle costs are the lowest in the table labeled "current." Further, as to total power cost, only two of the systems mentioned are believed to have a reasonable chance of achieving even minor economies during the next decade.

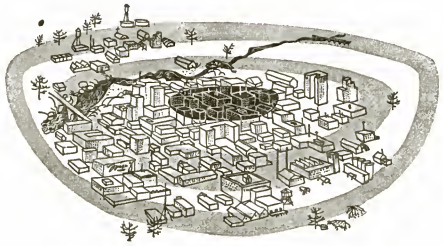
This is a pessimistic picture, but I am optimistic that toward the end of the 60's, or in the 70's, nuclear power plants will be built in quantity, with every expectation by the builders that this is the reasonable economic thing to do.

The boiling and pressurized water reactors are the most logical ones for private industry in the United States to exploit. Since the extra cost of power associated with their use seems slight, the provision of large nuclear capacity in these reactor types would have the advantage of providing insurance against fluctuations in fossil fuel costs. The development of oxide fuels can be expected to lead to acceptable fuel cycle costs, primarily because the industry has been jolted into putting a larger fraction of research support into problems connected with the fuel. For Canada and other countries which have relatively low capitalization charges to pay on public utilities, it is quite probable that the heavy water moderated reactors, fueled with natural uranium and arranged to allow a long fuel irradiation, will be the most economic for some time.

If one wanted to guess ahead at the distant future, one would make a completely different choice. Fast reactors will probably be dominant in the period of 25 to 50 years from now, due to their good capacity for breeding. Major competition at that time would come from the alternate breeder, the aqueous homogeneous reactor, and from the alternate high temperature reactors cooled with gas or liquid metal, or the high temperature fused salt reactors.

The other power reactors have sufficient potential so that a reasonable national strategy must continue their development. This has been supported by recent improvements in fossil fuel supply, which effectively delay the time at which a final decision among the various alternatives must be made.

As a final remark, it should be pointed out that the United States has other reasons besides cost reduction in the central station power field to develop nuclear energy. The public development must emphasize international obligations, special national interest, and resources. Thus, it is logical for us to support at the federal level for these respective purposes: continued development of heavy water reactors, which are more attractive under the economic ground rules of many friendly nations; submarine systems, space applications, exploration base and emergency package power plants; and breeder reactors, ore exploration, and systems of high thermodynamic efficiency.



Mass Fires following Nuclear Attack

A. BROIDO

IN THE United States, the first analyses of the damage produced by nuclear detonations all took the view that such weapons produced their awesome results primarily as a consequence of the blast wave. Further investigation indicated that heat effects might well contribute more damage for greater distances and with greater production of casualties than any expected blast effect. However, before the heat hazard could receive the attention it deserves, it was again relegated to a secondary position by the sudden recognition of the large area of involvement and the fearful loss of life that may result from radiological effects.

Recently, fire effects of nuclear attacks have again come into the limelight. For example, during the Holifield Committee hearings on "The Biological and Environmental Effects of Nuclear War," considerable testimony, some of it misleading, was given on the heat and fire consequences of an assumed attack. Thus, a realistic appraisal of these fire effects is in order. This article attempts to present such an appraisal, without glossing over the disastrous consequences which may occur, and yet without exaggerating a problem which is bad enough if considered conservatively. Although extensive damage will result whenever mass fires form, a brief review of the process of fire ignition by thermonuclear attack and the characteristics of fire spread from the original points of ignition suggests certain fire control measures which can be taken to minimize the over-all effects.

Fire Effects of Non-nuclear Bombs

By the end of World War II, it was generally recognized that fire effects are responsible for the greatest damage in a strategic air war.[1] This recognition was, however, far from instantaneous. As early as 1931 a German fire engineer, Hans Rumpf, wrote a book[2] which spelled out the role of fire in the destruction of cities in a future war, but his book was suppressed in Germany and ignored by the British and U.S. air forces. Even as late as February 1945, the small-scale incendiary attacks which were attempted against the highly vulnerable Japanese cities resulted in little damage compared to an equivalent high explosive attack and tended to conceal the great potential of fire raids. Only after a successful large-scale incendiary raid on Tokyo, was it recognized that to be effective, such attacks should be on a scale "sufficiently great to overwhelm the civilian and professional fire fighters, exceed the water supply available, and create such intense heat that fires would progress virtually unchecked until they reached open spaces."[3] In other words, it is the formation of a widespread conflagration that gives fire the greatest potential as a destroyer of life and property following an air attack.

Before World War II, several cities in Europe and in the United States were destroyed by fire. The difference between those fires and wartime fires like the one at Hamburg following the attack of July 27–28, 1943, is vividly described by Rumpf.[4]

In the following night, the sixth, an even heavier attack, caused the last organized defense effort to collapse. The Chicago and San Francisco fires and other great fires which have been reported by contemporaries in terrifying, fantastic, and horrifying images must pale before the size and

[1] See, for example, Percy Bugbee in the foreword to *Fire and the Air War*, National Fire Protection Association, Boston (1946).

[2] Hans Rumpf, *Brandbomben*, E. S. Mittler & Sohn, Berlin (1931).

[3] Forrest J. Sanborn, *Fire and the Air War* (Ref. 1), p. 171.

[4] Hans Rumpf, *Der Hochrote Hahn*, E. S. Mittler & Sohn, Darmstadt, Germany (1952), as quoted by Horatio Bond in a paper entitled "Wartime Fire Fighting" published in the proceedings of the Symposium on Fire Extinguishment Research and Engineering held at the U. S. Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, California, November 16–18 1954, and reprinted in *Quarterly of the National Fire Protection Association*, 48 (April 1955), p. 349.

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uniqueness of this Hamburg fire. There were 250,000 dwelling units completely destroyed out of 556,000—40,000 people had lost their lives.

Moscow had burned five days in 1812, the old city section of Hamburg four days in 1842, and San Francisco three days in 1906. Now the cities were being totally enveloped with fire and burned to the ground in a matter of hours. The only things remaining were broad fields of rubble, hollow buildings, empty facades of deserted streets of a ghost town—lifeless illusory settlements. The burnt city lay like a wasteland, full of bricks, rubble, dust, and old iron. Over an expanse of several square miles lay the crushed and charred ruins and only here and there could be seen, still standing, a five-story building or a single-house block. Up to this time, only the blind fury of nature had been able to wreak such destruction.

Before World War II was over, such total devastation had been inflicted a number of times, by conventional fires occur have been described by Rumpf[5] in his account many and Japan.

Effects of Mass Fires

Mass fires of the type to be expected in the event of nuclear attack consist of two types—fire storms and conflagrations. The awesome conditions resulting when such fires occur have been described by Rumpf[5] in his account of the fire storm which followed the raid on Leipzig:

> Such a species of natural phenomenon as this can alter the properties of the atmosphere so that organic life is no longer possible therein and ceases. We have become accustomed to calling this phenomenon a "fire storm." The single fires join, the heated air shoots upward as if in a giant chimney. The fresh air, sucked and rushing along the ground, creates a hurricane which in its turn fans the smaller fires and draws them into its course. The effects of such a hot column of air from a giant torch over a burning city were felt by flyers up to 13,000 feet in the air and described as stormy and unpleasant. The only possible comparison is with the storms of the tropics at the peak of the wind scale. Our latitudes do not know the strength and devastating effects of such hurricanes.
>
> Whoever has not himself experienced a fire storm will find it difficult to get a true picture from a description. At its edge are the conditions of a heavy storm. The roofs of trucks fly off, people's coats are pulled over their heads, those not standing firmly are knocked down. Approximately 2¼ miles from the edge of such a fire, a weather station has measured a wind velocity of 34 miles per hour which increased rapidly as one neared the fire area.
>
> At irregular intervals squalls arise which strengthen the impetus of the storm. There is swirling, splintering, and crackling everywhere; even from the buildings and street fronts spared by the fire. The resistance of the building sections, calculated up to 30 pounds per square foot, no longer suffices, a sign that a storm velocity of 75 miles per hour has been exceeded.
>
> Further in, life is practically impossible outside of protected buildings. Strong trees fall to the earth with splintering trunks, young trees are pressed to the earth like twigs. Hamburg lost 70,000 of its 100,000 street trees in this manner.

[5] Ibid.

Motion is possible only by crawling, and even that is difficult and dangerous. I remember how firemen trying to arise were thrown down and whirled away until they finally were left lying with broken limbs in some sheltered spot. We had terrible casualties. Again and again men were actually hurled into the air. The driver of a fire truck was lifted out of his vehicle and thrown to the pavement before my eyes. He died of a fractured skull that same night. We tried to send an automobile sedan across an open square from the protection of a garage. It was seized by the wind and, tumbling over and over like a box, was carried off with its occupants. The basement of our fire station was like a dressing station for troops in the front lines.

Fire storms of the type described by Chief Rumpf are expected to follow rapid ignition of large areas in the absence of a strong ground wind. Since the fire winds blow toward the center of the fire, there is usually little fire spread beyond the area originally affected. A conflagration, on the other hand, is a great fire which moves along the ground under the influence of strong winds. The column of rising hot air, once it has been established, slants appreciably to leeward and large numbers of firebrands shower upon the leeward region. Also, the higher the wind velocity, the more the column leans and the closer the hot and burning gases approach combustible materials on the ground.

The chief characteristic of the conflagration, therefore, is the presence of a fire front, an extended wall of fire moving to leeward, preceded by a mass of preheated turbid burning vapors and by a large number of spot fires ignited by the firebrands. Since the fire continues to spread in a downwind direction until it runs out of fuel, the total destruction by a conflagration may be much greater than that by a fire storm. However, beyond the area of original involvement, the characteristics of the fire (particularly in such factors as rate of spread and effect of firebreaks) become more like those of the large urban and forest fires of the past. Although some such fires have consumed thousands of square miles over a number of days, even without fire fighting they have reached natural barriers and have burned out—leaving vast areas unscathed.

Ignitions by Thermonuclear Detonation

A thermonuclear detonation can start fires both by primary heat effects (ignition by visible light and infra red radiation given off by the fireball), and by secondary blast effects (overturning of stoves, short circuiting of wires, etc.). Since fire can spread rapidly, essentially the same degree of damage could very well result from fires produced by either effect alone, and this has led to considerable confusion concerning the effectiveness of heat radiation in the production of fires. Additional confusion has resulted from the inability to produce sustained ignition by short pulses of heat radiation in many fuels normally considered highly inflammable. For example, a sound wood surface exposed to a short pulse of heat will char,

perhaps quite badly, and flames may often be produced during the application of radiant energy; but the temperature throughout the fuel will not be raised sufficiently to sustain ignition, and any flames which are started die out immediately after the exposure. On the other hand, such pulses of heat easily ignite many kindling fuels— thin materials such as dried leaves or shredded newspaper, or material like rotten wood which on the macroscale appear to be solid but which may be considered as consisting of an extended network of thin, porous inflammable material. Fires which originate in such kindling fuels may then ignite adjacent denser fuel.

The critical ignition energies for the various kindling fuels depend upon such factors as (a) the relative humidity and consequent moisture content of the fuel, and (b) the duration of the heat pulse (which lengthens with higher weapon yield). The heat energy irradiating an object some distance from ground zero depends upon such factors as the weapon yield, the height of burst, and the visibility of the atmosphere. The quantitative influences of these various factors are discussed elsewhere [6, 7, 8]; but by way of illustration, on a very clear dry day a ten-megaton nuclear airburst could produce heat ignitions out to distances greater than 35 miles. At these distances, blast effects would be limited to window breakage and other such minor damage. If kindling fuels were exposed throughout the entire region, the circular area of instantaneous heat ignition would be almost 4,000 square miles and would include large regions that would escape serious fallout effects from an equivalent surface burst.

Any solid opaque material, such as a hill, a wall, or a tree, between the fireball and the target will shield the target from heat radiation. However, a hazy atmosphere does not provide as much protection as has frequently been thought, because the dust particles in the air scatter (reflect) rather than absorb the heat radiation, and although the radiation is diffused it can still arrive at the target. Furthermore, unless a solid shield completely surrounds the target, it will not be entirely effective if a large portion of the heat radiation received has undergone "scattering" (reflection) and arrives from directions other than from the point of burst.

Fire Spread

Since an ignition point is of concern only if contiguous fuel insures the formation of a growing fire, the development of a mass fire following nuclear attack depends not only on the presence of kindling fuels, but also on the presence and spacing of all combustible material in the area. Consequently, fuel factors which affect susceptibility in conventional fires are also of concern in assessment of vulnerability of heat.

Perhaps the most important factors influencing the spread of fire in an urban area are building density, defined as the ratio of projected roof area to total ground area included in a particular region, and the size of the area included in each building density category. The three density categories that have been recommended[9] for use in fire analyses of urban regions are (1) 0 to 5 per cent, (2) 6 to 20 per cent, and (3) more than 20 per cent. The 0 to 5 per cent category comprises areas in which fires do not generally spread beyond the buildings in which they originate. If these areas are sufficiently large they constitute a major firebreak. The 6 to 20 per cent category comprises areas in which fires may spread beyond their point of origin, but are not expected to merge and form mass fires. In areas with more than 20 per cent building density, mass fires may develop provided the density extends over an area of at least a square mile. Over smaller areas, mass fires are unlikely even though the combustible contents of the area are completely burned out; but in considering such areas, the spread of fire from grass, brush, and woodland areas to additional urban complexes cannot be overlooked.

Considerable information has been obtained concerning fire spread from the many wildland fires which occur annually in the United States. Although ignition and spread of such wildland fires have been found to be highly dependent upon weather conditions, weather does not influence fire spread in urban complexes as much as has been frequently assumed.

For example, if one considers the danger from indoor ignition, one finds that the seasons considered safe in the case of forest fires are frequently the most dangerous in the case of nuclear attack. Thus, in the northern part of the United States the winter months are considered as a period of safety from forest fires. Yet during these months most buildings are heated; where humidifiers are not in use, the humidity conditions indoors are dangerously low, perhaps lower than they ever are outdoors; and the hazard from fire starting indoors is extremely high.

Even for outdoor fuels, high humidity during the period preceding the attack is important only in the beginning stages of a fire. However, kindling fuels are quite

[6] A. Broido and C. Trilling, "Thermal Vulnerability of Military Installations," U. S. Naval Radiological Defense Laboratory report TR-101 (August 1955).

[7] F. M. Sauer, C. C. Chandler, and K. Arnold, "Primary Ignitions following Atomic Attack on Urban Targets," U.S. Forest Service interim technical report AFSWP-413 (June 1953).

[8] Samuel Glasstone, editor, *The Effects of Nuclear Weapons*, U. S. Atomic Energy Commission (June 1957).

[9] U.S. Civil Defense, *Civil Defense Urban Analysis*, TM-8-1, U. S. Govt. Printing Office (July 1953).

thin and respond quite rapidly to changes in humidity. Thus, a very short period of sunshine, even after the heaviest rains, will dry out many of these fuels. In fact, the energy in the heat pulse itself can dry out and then ignite the kindling fuel at only a slightly higher energy level than would have been required had the fuel been dry. Once a fire is well established, it can readily overcome the retarding effect of moisture in heavier fuels. In fact, studies conducted during the last war indicate that even when rain was falling during conventional fire bomb attacks, the damage produced averaged only 20 per cent less than that produced under favorable weather conditions.[10]

Fire Control

In this article, the term "fire control action" includes all steps taken before or after a nuclear attack which will tend to minimize the fire effects of such an attack. Appropriate fire control action may be directed along three lines, namely, (1) reduction in number of potential ignitions, (2) provision for isolation or rapid extinguishment of ignitions to prevent formation of serious fires, and (3) minimization of fire spread potential should large-scale fires be produced. Incidentally, any one who feels that, if any fires should be produced in an attack, the safe construction practices in the United States will keep our cities from burning as readily as did the highly combustible Japanese cities may be disillusioned upon learning that the structures that make up our major cities range from more than 99 per cent combustible construction in San Francisco to a low of 96.4 per cent combustible construction in Washington, D.C.[11]

Effective fire control steps which may be taken range from very simple ones, readily put into effect, to complex and costly ones. For example, reduction in the number of potential ignitions may be accomplished by removal of kindling fuels. The elimination of wood as a construction material and its replacement by concrete, brick, and metal, of course, is one step (a rather expensive one) in this direction, but continuous upkeep of existing wood structures to prevent the exposure of rotting wood is a cheaper step in the same direction.

The effectiveness of eliminating kindling fuels in reducing ignitions was rather strikingly demonstrated in a civil defense experiment during Operation *Upshot Knothole*, the atom bomb test series conducted in Nevada in 1953.[12] Three mock-up frame houses were constructed at identical distances from ground zero and exposed to one shot during that operation. One of the houses was well maintained and had a painted wood siding and a clean yard. Another house had a clean yard but had unpainted, weathered, decayed siding. The third house was poorly maintained and was surrounded by adjacent dry weeds and trash. After the detonation, the first house showed only mild scorching and was not significantly damaged. The second house suffered smoldering ignition which later burst into flames and consumed the building. The third house was ignited and quickly consumed.

If kindling fuels cannot be eliminated, shielding of such fuels from a heat flash is an effective means of eliminating the danger. Thus, ignitible trash in covered metal containers will not be ignited by a heat flash. Covering windows in existing structures or constructing windowless buildings can minimize ignition of internal kindling fuels. Shielding of large regions by smoke screens may effectively reduce vulnerability to heat, wherever the smoke is dense enough to reduce the energy delivered to levels below critical, provided (1) the screen can be laid down before the detonation, (2) it is large enough to minimize the probability of fire spread to the covered area, and (3) it is sufficiently low so as to not greatly increase the heat reaching the target as a result of downward "scatter" from smoke above the fireball.

Once the number of potential ignitions has been reduced to a bare minimum, the next major step is to plan and train for the elimination of these small ignitions before they can grow into serious fires. Those ignitions which occur remote from any large combustible complex may be allowed to burn out with minimal over-all effect. Since all other ignitions must be extinguished promptly (at Hiroshima the initial fires had merged to mass fire proportions in about a half-hour), the job of firefighting cannot be left to a fire department which proceeds with a small number of major pieces of equipment to the scene of each fire after it has been reported. Rather, a first aid type of firefighting must be adopted. Everyone must be taught to act promptly after the immediate effects of a detonation are over and to try to extinguish all such incipient fires within his immediate reach. In the first few minutes many of these fires can simply be stamped out. Small fire extinguishers, readily available, or even buckets of water or sand are extremely useful in these early times. If each person extinguishes enough of these small fires early enough, perhaps few will grow sufficiently large to require the services of a professional fire department.

It is important to spread out the tools which must be used to combat fires and to take considerable care to insure that the facilities are properly located and truly independent. For example, many urban areas utilize a single water supply. A break in the water main at one place would completely eliminate the water supply to such an installation. Even if several independent supplies feed into one common system the entire supply may be wasted if it is impossible to cut off a part of this system. Thus, the official report of the U. S. Strategic

[10] Sanborn, op. cit., p. 178.

[11] U. S. Civil Defense, *Fire Effects of Bombing Attacks*, TM-9-2, U. S. Govt. Printing Office (August 1952).

[12] U. S. Civil Defense, *The House in the Middle* (1953). (Motion picture, available from the Office of Civil and Defense Mobilization.)

Bombing Survey[13] concerning the bombing of Hiroshima contains the following paragraph:

The water reservoir, which was of reinforced concrete and earth-covered, was undamaged; it was nearly two miles from the blast center. However, 70,000 breaks of pipe connections in buildings and dwellings were caused by blast and fire effects. No subsurface pipes were crushed and no leaks resulted from blast as a direct cause, though several leaks in underground mains resulted from falling debris. Pressure in the city center dropped to zero because of the connection breaks and the damage to a 16-inch and a 14-inch water main where they crossed damaged bridges.

Even after everything possible has been done to minimize the probability of formation of large fires, steps should be taken to minimize the effects of these fires should they occur. Natural firebreaks must be utilized to provide the utmost in fire protection (whether or not they ultimately prove to be effective). Highly combustible regions must be eliminated as soon as possible.

Finally, considerable research and training effort must be expended on techniques for the fighting of such mass fires. That firefighting is not completely hopeless has been indicated by Chief Rumpf[14] in his description of the Hamburg fire:

Often the fire stopped only when it found no more fuel—even if the battle against the fire was hopeless in the center of the gigantic area fires, on their periphery, and in countless individual locations; gradually here and there, the fire fighting began to show results. Individual structures, house blocks, lines of streets, and whole districts were saved. These would certainly have been destroyed had it not been for the efforts of the fire fighting forces. Thousands and tens of thousands of families here, and in the other cities, are today indebted to the fire departments for their homes—the safety of their saved dwellings. So, taken as a whole, the efforts even in Hamburg have not been completely in vain.

Conclusion

This article has attempted to give some insight into the awesome destruction which may be expected as a result of fire effects of a future nuclear attack. Although very little of mankind's past experience with fire is directly applicable to a prediction of what may be expected, a look at the mass fire experiences of the past cannot fail to help anticipate many of the conditions that will prevail in the future. Thus, the over-all fire effects following nuclear attack will most certainly depend upon the number and distribution of ignitions produced; the weather, fuel, and topographic features which influence fire spread; and the fire control action taken, both before and after the attack.

In a recent paper exercise involving a simulated attack on the western part of the United States, the author assisted in the assessment of fire effects of the simulated strike. The assigned effects varied greatly with location. On the basis of extreme weather and fuel conditions in the Los Angeles area, it was concluded that the fire would burn at will from ocean to desert. In the San Francisco area, the fire was held to 200 square miles (unfortunately, including most of the urbanized Bay Area). However, in Portland, Seattle, and a number of other points, a combination of favorable circumstances (on paper, at least) kept estimates of fire damage to a fairly low level. Further, careful analysis of the results of this exercise indicated the much greater reduction in effects which would have been possible had additional pre-attack fire control action been taken.

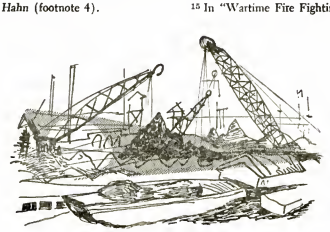
Although past attempts to stimulate study and action have been most discouraging, it is hoped that more widespread distribution of information on the fire consequences of nuclear attack will help combat the situation so aptly described by Horatio Bond, Chief Engineer, National Fire Protection Association.[15]

We have been living, since World War II, in an atmosphere which in some ways is a little hard to explain. Many of the lessons of the last war and of the A-bomb and H-bomb are perfectly plain. They pose to everyone some very serious problems. Solution of many of these problems means radical change in how we build our cities and how we run our fire departments. Rather than face the necessity for making any of the obvious changes, most citizens and officials of government—federal, state, and local—have preferred to ignore the problem of modern war. Some problems, if ignored long enough will go away. I wish the same could be said of these.

[13] U. S. Strategic Bombing Survey, *The Effects of Atomic Bombs on Hiroshima and Nagasaki*, U. S. Govt. Printing Office (June 1946).

[14] Hans Rumpf, *Der Hochrote Hahn* (footnote 4).

[15] In "Wartime Fire Fighting" (footnote 4).



Incomplete Deterrence

FREDERICK MARTIN STERN

The articles by Raymond Aron, Klaus Knorr, and Alastair Buchan on "The Future of Western Deterrent Power" in the *Bulletin's* September issue lead to the conclusion that the present deterrent power of the West is inadequate for two basic reasons: first, because of its one-sided structure, and second, because "the West" that faces the monolithic Soviet bloc is far from being monolithic.

This one-sidedness appears in the high priority given to heavy weapons systems, and the neglect of conventional and subconventional forces. Billions of dollars are—and must be—poured into strategic air, naval, and missile forces equipped with large and medium-scale nuclear weapons; and also into mobile ground forces of great fire power, equipped partially with tactical atomic weapons. Yet the comparatively small amount of money needed to create the territorial forces and effective, ready army reserves that should protect the free nations from Communist upheavals or incursions of lesser or paramilitary forces are denied.

It would seem that the concept of "deterrence" has been warped by the circumstances under which it has recently been used. Deterrence was always an aim of defense planners, but in our day the horrors of Hiroshima and the thermonuclear bomb have captured everyone's imagination to such an extent that most people concentrate almost exclusively upon deterring atomic attack, neglecting the kinds of aggression which the Communist powers are constantly committing in many places. This has led to a situation reminiscent of the one that prevailed in England right before the Second World War, when the nation was busily preparing itself for a German attack with gas—which never occurred—but remained gravely deficient in the forces and weapons needed to meet the attack that actually occurred. Today the West has built its defenses into the sky—and beyond—but has neglected the structure needed to control aggression on the lower levels.

Europeans are not satisfied with the availability of mobile divisions and atomic weapons since it does not seem justified or practical to use them to counter or deter Communist "political" movements aimed at internal unrest. They cannot forget that the conquest of Czechoslovakia and North Vietnam and the attempts against Greece, Malaya, Guatemala, Iraq, and other countries were made or started by "political" or paramilitary forces employing and threatening murder, kidnapping, and other kinds of common violence. The misgivings of the NATO nations should not be taken lightly, for even low-level violence can lead to all-out, or in our day, to nuclear war—especially if only heavy weapons systems are available to counter low-level violence.

Problems arising from the individual sovereignties of the Western nations intensify the weakness caused by the one-sided structure of Western deterrent power, and these problems themselves are compounded by that structure. If the fifteen NATO countries represented one united empire or commonwealth, or a federal union like the U.S., whose every member state could be sure that any incursion or disturbance would unfailingly be answered by the central government with appropriate and effective measures, the weakness of preparations for meeting minor violence or limited conventional war might be less serious. But separated as they are by their individual sovereignties, the nations are aware that the Communist empires could strike dangerous blows without employing the kind of violence that is sure to invoke full-scale military action by NATO. The "trip wire" might not ring a bell; and even if it did, they know that every state, being sovereign, can renounce or break its foreign commitments; recent, and *very recent*, history has demonstrated the instability of alliances and supranational structures. Moreover, they may shudder at the thought of being aided or liberated by means of nuclear weapons.

Frederick Martin Stern is the author of The Citizen Army, Key to Defense in the Atomic Age.

Filling the Gap

Now, if we cannot break the interaction of plural sovereignty and one-sided preparedness in the near future by having all, or even a majority, of the NATO countries united in one single sovereign structure, we must tackle the problem from the other end, by filling the gap in the Western deterrent and supplementing it with forces of low-level deterrence. This is doubly necessary since the Communist powers are carefully avoiding any action that would invoke the use of nuclear weapons.

Moreover, the regular forces of the West, even if they were doubled, would be incapable of coping with the combination of political, psychological, and economic pressure with ruthless violence and terror that has been developed by Lenin and his disciples. Therefore the problem that must be answered is how the nations which, due to their geographical location or to internal conditions, are primarily exposed to the threat and activities of the Communist powers can be organized to meet and deter the lesser degrees of Communist violence.

Despite the impasse in which the NATO members find themselves, it seems amazing that the creation of strong, ready reserve and territorial forces along the lines of the inexpensive citizen army system developed by Switzerland and other countries has been given hardly any thought—particularly since men like General Marshall, General MacArthur, Lord Roberts, and Captain Liddell Hart have recognized its great value and have urged its adoption as a complement to the regular forces.

Actually, what has led most political and military leaders to accept Western weakness in conventional and territorial forces as "inevitable," is mainly the prevailing welter of misconceptions about the character, cost, and effectiveness of a real citizen army. These mis-

conceptions would probably not exist if people understood the fundamental difference between a real citizen army and a mere militia or a semi-professional army of the Prussian type.

Part of this confusion is due to the lack of a clear terminology. By "citizen army" I mean an army whose members are recruited in peacetime by universal obligation, trained in a minimum of time, kept in a high degree of readiness for years through refresher courses, and trained and commanded primarily—though not exclusively—by well-chosen and well-instructed officers and NCO's, who are themselves primarily civilians. A "militia" would refer to imperfect citizen formations recruited on a volunteer basis, or formations drafted hastily in an emergency when there is neither time nor a competent staff to train them. In addition, the citizen army is often confused with the semi-professional or cadre-conscript army as first developed by Prussia in the nineteenth century—an army whose cadres consist of professional soldiers, while the rank and file (and in wartime, part of the lowest ranking cadre personnel) are drafted civilians.

While the main differences between the citizen army and the militia are quality, strength, and readiness potential, the difference between the citizen army and the cadre-conscript army is to be found primarily in the cost of the latter, and in the unpopularity of a system that imposes much unnecessary soldiering and time-wasting upon its conscripts. The principles developed by Prussia are not valid for the creation of a competent military force, and should not be allowed to influence Western military preparations.

The power of a citizen army which is well trained and organized in time of peace is usually grossly underrated. Even if the Swiss example seems invalid—though experts have come to admire it—the performance of the citizen armies of Israel, Australia, New Zealand, and Canada cannot be ignored. And the recent announcement by the Swiss government that its army of 500,000 will be reorganized into twelve mobile divisions equipped with 500 tanks contradicts critics who believe that such an army can only be used for static defense. As to quality of the personnel, most critics forget that training, no matter how protracted, can never replace the inborn qualities of men. By drafting every able-bodied man and training many, in the absolute minimum of time, for the highest specialist, staff, or command positions commensurate with their abilities, a citizen army has a wealth of talent at its disposal that must be the envy of many professional or semi-professional establishments.

It seems imperative, therefore, that the European NATO powers give serious consideration to the creation of Swiss-type citizen forces recruited by universal obligation. These forces would not have to be equipped with the latest and costliest armaments and equipment; for in a clash of greater magnitude—even in a "limited" war—they would be backed up by the mobile divisions and, if needed, by the air, missile, and atomic weapons of the Western alliance.

The Strength of a Citizen Army

Once such a strengthening of the conventional forces is achieved, many problems now besetting the West will appear in a different perspective. For instance, if at every point of the frontier and of the interior, well-organized citizen forces can go into action against any overt or covert enemy coup—immediately, at any time—the mobile divisions of NATO will be relieved of many duties they have now to perform. Surrounded by an effective screen, they will not be in danger of dissipating their strength in minor actions, and will find their mobility and power greatly enhanced. Above all, they can reserve atomic weapons for use as a means of last resort, instead of planning to use them at the outset. Of course, we never know whether what looks like a minor or limited conflict will grow—and be planned by the enemy to grow—into a major or world-wide war. But we will no longer be forced by lack of conventional and sub-conventional forces to enlarge a conflict by stepping up the degree of violence. A good deal of the anxieties and misgivings now besetting the people of NATO countries will thereby be put to rest, and NATO unity will be reinforced.

Finally, the creation of territorial and reserve forces of the citizen army type will bring the appearance of the Western defense structure into line with the purely defensive intentions of the Western powers. Nobody plans aggression against the Soviet Union or its satellites. But the people of the Communist countries may not be fully convinced of the peaceful intentions of powers whose military posture shows, in spite of the emphasis on heavy and atomic weapons, few preparations of a tactical defensive nature—while the Soviet Union has organized its civil defense and its territorial and reserve formation on a very large scale.

By closing the current gap between its intentions and its appearances, the West would give the lie to Communist propaganda about Western aggressiveness. The ensuing reduction of the anxieties that may from time to time beset the Communist leaders and their people would help reduce the danger of a "preemptive" surprise attack upon the Western nations. A more defensive complexion of the Western deterrent could conceivably bring about a relaxation of East-West tensions, and help create the psychological atmosphere that must precede fruitful negotiations concerning arms control and disarmament.

Here, then, we have a measure that could be taken unilaterally, and would at once strengthen the Western Deterrent Power and the chances of peace.

Project Plowshare: Peaceful Uses of Nuclear Explosives

IT IS NOW possible to gain more than a newspaper reader's understanding of the facts, thinking, and speculations which have been the basis for one body of opinion in this country which wants to hold off an agreement to stop nuclear explosions entirely. There is a set of five AEC reports UCRL–5675 thru UCRL–5679, collectively called "Proceedings of the Second Plowshare Symposium, San Francisco, May 13–15, 1959," which offers the reader knowledge, entertainment, and enlightenment. After reading the second and third of these reports, your reviewer can't decide whether it is the heady air of California that has caused the contributors to throw caution to the winds, or whether the AEC chose to document what was in essence a scientific salesmanship session in order to arouse public interest. There was a great deal of speculation, hunch-backing, and back-of-the-envelope calculation indicating a starry-eyed curiosity as to what indeed would happen when a nuclear device was exploded in a salt bed. Some useful heat might be extracted but economically it can be successful only if very large explosions are used. If one uses the AEC cost figures, one million BTU of heat cost $12.50 when it comes in 10-kiloton explosions, only $0.25 when it comes in 1-megaton explosions, about $0.03 when in 10-megaton explosions. The same amount of heat from fossil fuels will probably cost between $0.20 and $0.25 during the next decade or two.

Technically there is considerable uncertainty as to the means for transferring the heat out of a deep underground cavity. If the explosions occur in a salt bed, there will presumably be a pool of molten salt left in the bottom of the cavity; and this will cool slowly unless the top of the cavity falls in. There was talk of re-use of the same cavity, with attendant saving of heat, but there were no realistic considerations of how this could be managed.

Some isotopes would be created but the yields are ridiculously small (of the order of 20 grams per kiloton of explosive energy) and the material is dispersed in something like 500 tons of molten rock —even if the rock is salt, it would cost something like $200 per gram of isotope to extract it, which is of the order of ten times as expensive as the cost of one isotope, plutonium, which is certainly very valuable but can be produced in reactors.

It was perfectly clear that excavating could be done by nuclear explosives more cheaply than otherwise. An example of excavation is given in the facts quoted about one of the Nevada Test Site explosions: "Teapot Ess, 1.2 kilotons was shot in 1955 at a depth of 67 ft and produced a crater 292 ft across and 90 ft deep." Perhaps one-quarter of the material that was excavated landed on the lip of the crater; the rest distributed itself thinly about the landscape. Based on this shot and a couple of others at different depths, Project Chariot has been proposed, to excavate a harbor in an unpopulated region along the northwest coast of Alaska, 110 miles north of the Arctic Circle. "The excavation as now planned would be accomplished by simultaneous detonation of five nuclear devices. The main bowl of the harbor will be formed by two 200-kiloton devices buried at an actual depth of 700 feet and spaced 775 feet between centers. The entrance channel would be formed by three-kiloton devices buried at approximately 375 feet deep and spaced 408 feet apart. All of these devices would be emplaced in a 36-inch diameter cased hole . . . . each device will be tamped with high-density, low-freezing-point drilling mud. The devices are calculated to produce an area equivalent to a turning basin approximately 950 yards long and 550 yards wide and an entrance channel approximately 950 yards long and 250 yards wide." Assuming a required depth of 30 feet, the total useful volume of excavation would be about 5 million cubic yards.

No cost estimates were quoted for the Alaskan excavation, which is intended solely as a demonstration of what could be done. The Symposium on the whole, however, was quite cost-conscious. As a guide, the AEC had released several items of information such as the two following:

"The service charge for an energy release of a few kilotons (all from fission) would be $0.5 million. The diameter of this nuclear assembly is 30 inches."

"The service charge for an energy release of several megatons (5 per cent fission, 95 per cent fusion) would be $1.0 million. The diameter of this nuclear assembly is 60 inches."

There were dollar signs aplenty in a proposal for digging a sea-level ship canal across the Isthmus of Panama about 110 miles east of the present Canal. The proposed canal would go through land up to 410 feet above sea level, and would be 46 miles long. No less than 651 nuclear devices would be fired, of total yield 42 megatons. Cost of the explosives would be $505 million, cost of drilling placement shafts would be $36 million, and the cost of the entire canal would be $2.1 billion—less than half the cost of $5.1 billion if excavating were to be done by past conventional means.

The Panama proposal blithely disregarded the public repercussions that would surely follow such an extensive set of nuclear explosions in a not unpopulated country. The Alaska project, on the other hand, will occur in a quite deserted region, with only four settlements (total population less than a thousand) within 100 miles of the explosions. Even at that, considerable caution is promised regarding proper wind directions so that no fallout will drop on these settlements (such excavation shots will release about a tenth as much radioactivity into the air as ordinary air bursts the same size would release). Shock waves in air and ground are also to be handled with care.

Yes, interesting reading, indeed!

—JOHN R. STEHN

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This is a slightly modified version of a review that appeared in *Mass Newsletter*, May 28, 1960.

Specialized Pamphlets

Review of the International Atomic Policies and Programs of the United States. Report of the Joint Committee on Atomic Energy, Congress of the United States. Volume 1. By ROBERT MCKINNEY. Washington 25, D.C.: U.S. Government Printing Office, October 1960. Pp. 78. 35 cents.

The impact of this very serious and profound study of international relations in a field essentially technical is bound to be great. Congress in its next session will certainly give it thorough consideration. It is the result of a year's survey by Robert McKinney, editor and publisher of the Santa Fe *New Mexican*, who was the first permanent representative of the U.S. to the International Atomic Energy Agency (Vienna) and chairman of the nonpartisan citizen's panel which submitted the "Report on the Impact of the Peaceful Uses of Atomic Energy" to the Joint Committee in 1956. The Review's findings, conclusions, and recommendations will be found in this brief first volume; supporting documentary material running to 2,000

pages is contained in the other four volumes.[1] Since the *Bulletin* will have an article by Mr. McKinney in a later issue, highlights only of the Review will be mentioned here.

Mr. McKinney believes that the Atoms-for-Peace program of the U.S. has failed because it was composed of scientific and technical undertakings which should have been carried forward on scientific and technical levels free of excessive buffering at diplomatic and administrative levels. He recommends a much closer cooperative effort between the U.S. and nations of North America and Western Europe which are advanced in atomic technology. Policy makers from all the countries should agree on over-all research objectives in the peaceful atomic field; laboratory directors and technical program directors should have regular, frequent, and direct relationships; U.S. domestic activities at the frontiers of atomic technology should be planned in collaboration with our Canadian and European friends just as the broad scientific objectives of the U.S. program should take into consideration their laboratory capacities.

Of overriding concern to Mr. McKinney is the search for low-cost atomic power. He recommends that the U.S. national laboratories, in concert with those of our allies, concentrate their advanced experiments on this search, not only with reactors using conventional steam and gas turbine cycles but also with direct conversion systems, controlled fusion systems, and other advanced concepts. He urges research on special purpose atomic power applications such as propulsion which may give the experience for achieving low-cost central station power. Major experiments and prototypes now under way which are transitional to low-cost power, he would like pushed and expanded wherever possible through joint international projects.

A startling recommendation, because not much has been heard about it, is in the *non-power* atomic field. McKinney recommends that the next general Atoms-for-Peace conference be oriented toward the civilian *non-power* applications of atomic energy with special emphasis on the use of atomic materials in research, the life-sciences, and industry. He says that the technical papers in this area prepared for the Review by the AEC are incomplete and generally inadequate.

Most dynamic of McKinney's ideas is perhaps directed to broadening East-West technical relationships. He recommends that the next international conference on civilian atomic power be organized under the aegis of the IAEA rather than the U.N. and that it be held in the Soviet Union in 1962.

—H.C.A.

[1] Requests for volumes 2–5 should be sent to Mr. James T. Ramey, Executive Director, JCAE, Room F-88, Capitol Bldg., Washington 25, D.C.

Conference on the Discontinuance of Nuclear Weapons Tests. Analysis of Progress and Positions of the Participating Parties, October 1958–August 1960. Washington, D.C.: U.S. Government Printing Office, October 1960. For Subcommittee on Disarmament of the Committee on Foreign Relations of the U.S. Senate. Pp. 110.

A more timely release than this staff study from the subcommittee headed by Senator Humphrey cannot easily be imagined. Using the verbatim records and documents of the Geneva test ban conference, he has given a detailed discussion of the unresolved issues before the conference together with the position of East and West on each issue. Also set forth are the treaty articles that have been adopted and the drafts of articles submitted by the three countries but still under negotiation. All these articles are presented in chart form with positions of East and West in parallel columns.

The areas of disagreement (25 items were listed by the U.S. in March 1960) concern the control and inspection system to monitor the agreement. One sees at once that the great impediment is the difference in thinking between East and West. The U.S. thinks that with our present knowledge (or lack of knowledge), a control system is difficult to achieve without having it enormously complicated and requiring a very large number of on-site inspections. The USSR thinks that a control system can be very simple and its objective has been to keep to the minimum the number of control posts, the number of foreigners, and the number of mobile on-site inspections in the USSR.

Senator Humphrey (writing in the preface) says that both sides have engaged in lengthy delays at the conference. The U.S. has been plagued with ambivalence of purpose, one day seeming to want to conclude a treaty as soon as possible, the next acting as though progress in negotiations would be to our disadvantage. The USSR suffers from a rigidity of stance and an attitude of suspicion. It tries to have the best of two worlds: wanting the West to concede or pay twice as much when it comes to the number of inspections or financial contribution to pay for the control system but demanding equal ratio between the USSR and the West when it comes to the composition of the control commission or the staffing of the control posts. Yet both sides have made substantial progress. Humphrey believes that with continued efforts augmented by a modest amount of reasonableness, a test ban treaty that would not detract from the security of the participating nation could be concluded. (Members of the subcommittee besides Humphrey are: John F. Kennedy, Albert Gore, Frank Church, Bourke B. Hickenlooper, George D. Aiken.)

—H. C. A.

The Scientist in American Industry. By Simon Marcson. Princeton, New Jersey: Princeton University (Department of Economics, Industrial Relations Section), 1960. Pp. 158. $3.00.

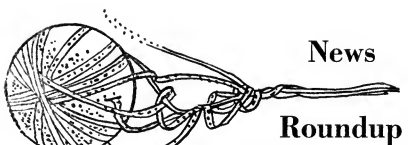
It is well known that the scientist with his stubborn independence and loyalty to research goals poses a problem for industrial laboratories: some can adjust and some cannot. This study describes the working environment of a large industrial laboratory, analyzes the professional needs of scientists, defines the sources of strain in opposing systems of authority, and offers in solution a blending of the principle of "executive authority" with "colleague authority."

Science in Space. The Biological Sciences and Space Research. Report of Space Science Board. Washington, D.C.: National Academy of Sciences—National Research Council, 1960. Pp. 19.

This is one of nine chapters of a survey of opportunities for important research studies using space vehicles. It is addressed to research scientists with the hope that it will increase their understanding of the "extraordinary vista of our times," in the words of Lloyd Berkner, chairman of Space Science Board, "in which scientific experiments can be carried out on a scale of interplanetary dimensions." It offers the lay reader, too, great enlightenment. In this chapter, for instance, the hazard of contamination *to* the Earth from foreign organisms brought *back* from Mars (say) when roundtrip manned flights become possible is briefly assessed.

Testing and Taming of Nuclear Weapons. By David R. Inglis. Public Affairs Pamphlets, 22 E. 38th St., New York, N.Y., 1960. Pp. 28. 25 cents.

This is the best type of popular introduction to a complex and prejudice-surrounded subject. It is truthful, brief, and eloquent. Inglis is a scientist who knows a great deal about the subject. He gives short factual accounts of the horrors of nuclear war, fallout, underground testing, techniques of test control, and other methods of arms control such as elimination of stockpiles and delivery systems and controlling the production of fissionable materials. He states the case for an international ban on testing based on a reasonable control agreement without distortion, not ignoring other positions and not hiding the many uncertainties involved.



News Roundup

Prepared by
ANN WIDDITSCH

DISARMAMENT AND ARMS CONTROL

Future of Disarmament Talks Uncertain.—In a tense and dramatic atmosphere President Eisenhower, Premier Khrushchev, and Prime Minister Macmillan spoke to the U.N. General Assembly on disarmament in late September and early October. The U.S. proposals (originally prepared for the 10-nation Geneva disarmament conference which collapsed in June (see September *News*) included gradually closing down production of fissionable materials for weapons and/or transferring 30,000 kilograms of U-235 from weapons stockpiles to peaceful purposes, provided the USSR would do the same and adequate controls were established. The plan also calls for agreement to prohibit putting into orbit or stationing in outer space weapons of mass destruction. These proposals had been presented before the U.N. Disarmament Commission on August 16 and were then rejected by the Soviet delegate on the ground that the U.S. was still advocating controls without disarmament. Premier Khrushchev's plan was the same as that submitted by the Soviet Union to the conference in June, calling for elimination of all means of delivering nuclear weapons in the first stage of the program. The USSR also proposed that the 10-nation conference be increased by the addition of India, Indonesia, the United Arab Republic, Ghana, and Mexico. Striking a somewhat different note, Prime Minister Macmillan suggested that the Assembly appoint a board of technical experts along the lines of that negotiating for a ban on nuclear weapons tests. Other suggestions were made. President Sukarno of Indonesia offered mediation by the African and Asian nations. Prime Minister Diefenbaker of Canada suggested that a neutral country preside over the East-West talks. Prime Minister Nkrumah of Ghana proposed a system of inspection by citizens of small uncommitted nations, and the Danish delegate suggested establishing an inspection and control system immediately, offering his own country as a field for testing.

On October 11 the General Assembly rejected a demand by Premier Khrushchev that it take up disarmament itself instead of referring the question to the Political Committee. (The Committee, on which every nation is represented, hears detailed arguments on subjects assigned to it, and can adopt draft resolutions for Assembly consideration.) After his defeat the Soviet premier warned that the Western powers had brought the world closer to war by their "victory" in the debate. On October 13 he threatened to withdraw from the disarmament discussions unless they were based on a draft resolution which endorsed his year-old proposal for "general and complete disarmament." The proposal also calls for equal representation of the Communist, Western, and neutralist nations in both the U.N. Secretariat and the Security Council. (Mr. Khrushchev had earlier proposed the abolition of the office of Secretary General, substituting a triumvirate representing the three blocs.) The Premier then left for home. On October 14, the United States, Britain, and Italy submitted a draft disarmament proposal to the Political Committee, similar to earlier proposals in its emphasis on a step-by-step program with "effective international control." Valerian Zorin, head of the Soviet delegation, repeated Mr. Khrushchev's threat to boycott the discussions if the committee should "waste time" on futile proposals such as those put forward by the U.S. Similar threats were made by Vaclav David, Czechoslovakian foreign minister, and Adam Rapacki, foreign minister of Poland. However, a meeting was scheduled for October 28 between U.S. Ambassador James J. Wadsworth and Mr. Zorin to discuss the possibility of reopening the disarmament negotiations broken off in June. The meeting, which had to be postponed because of Mr. Wadsworth's bronchitis attack, was suggested by him after a group of uncommitted nations, including Asians, Africans, and some Europeans, had urged a compromise on the disarmament resolutions under discussion in the Political Committee. Many of the smaller powers feel that there are areas of agreement between the Eastern and Western blocs which have been enlarged in previous negotiations, and that an attempt should be made to proceed on this basis.

Test Ban Developments.—On October 17 the U.S., USSR, and Great Britain formally approved the legal framework of an annex for the nuclear weapons test ban treaty. The annex sets out the privileges and immunities of the projected control organization, and is the second annex to be agreed to, in addition to seventeen articles and a preamble. A third, more controversial, annex not yet agreed to deals with the technical details and actual operations of the monitoring system. Other points currently under discussion at the Geneva negotiations are the timetable for the installation of controls, a veto on candidates for the control organization, and the extent of the area to be covered in investigating suspicious events. Meanwhile, the Administration announced on October 3 that the U.S. would soon begin tests aimed at improved detection of underground nuclear explosions. The program, Project Vela, calls for both nuclear and conventional explosions. The USSR originally agreed to cooperate in a joint program (see September *News*), but later withdrew, saying that it would take part in the U.S. program. It is not yet known if the U.S. will invite Soviet participation under these circumstances. John R. McCone, chairman of the Atomic Energy Commission, reported that construction of the test sites is proceeding, and that one of the seismic stations is almost finished, and added, when asked if he thought the Soviet Union was conducting underground nuclear tests, "my surmise is that since there are so many advantages to them and there is no means of detection, and the costs are very moderate, I can surmise that they are proceeding in the absence of any proof that they are not." Semyon K. Tsarapkin, the Soviet negotiator, charged that "Mr. McCone made this unfair allegation because he wants to draw a picture of the situation that will enable him to achieve his aim of resuming nuclear testing." Senator John F. Kennedy said on October 9 that he did not believe that underground tests of nuclear weapons should be resumed immediately (see Nov. issue, inside back cover).

ATOMIC POWER

Dresden Plant Starts Operation.—Commonwealth Edison's 180,000-kilowatt boiling water reactor at Dresden, Ill., the world's largest operating peaceful atomic power plant, was dedicated on October 12, a year after the reactor first went critical. It is ready for full operation. Rep. Melvin

Price (D., Ill.), a member of the Joint Committee on Atomic Energy, in a speech at the dedication, called it the "first full-scale plant built under almost normal commercial business relations and therefore the first opportunity to obtain actual operating data under commercial operating conditions." The cost of the plant has not been revealed. It is estimated, however, that the cost of power to the utility as of 1964 when the second reactor core is installed will be about 7.5 mills/kwh, and during the early years costs will be substantially higher. There was no direct federal assistance for the Dresden plant, but it will benefit from low-cost federal fuel loans, fuel reprocessing and public liability insurance, and from government purchase of by-product plutonium, and federal research and development. (*At. Power NL*, 10/14)

DEFENSE AND STRATEGY

Whither NATO?—North Atlantic Treaty Organization members have agreed to establish a unified air defense command for Western Europe. This means that General Lauris Norstad, Supreme Allied Commander in Europe, will be able to call into action at any time all the air defense forces in Western Europe. The long-sought unified command could not be set up before because of President de Gaulle's refusal to yield national control of his forces to an integrated international command. In the new compromise, only the French air defense forces stationed in Germany and in the eastern frontier provinces of France will be in the integrated command, while those in the rest of France will remain under French command. The new hope for NATO accord following this compromise was dealt a series of blows in a number of subsequent speeches by the French president, who not only demanded veto rights for France over the use anywhere of nuclear weapons by the West, but reiterated his refusal to permit atomic weapons under joint U.S.-French control on French soil. (Agreements of this sort have been worked out with Britain, Turkey, and Italy, and are being negotiated with Norway and Denmark; nuclear warheads in West Germany are under control of U.S. forces there.) Western leaders feel that de Gaulle's insistence on such a large measure of independence will endanger the commitment of the other Allies to NATO—despite a later softening of the veto demand to apply only where there was a question of the West's using nuclear weapons without having first been attacked with such weapons. There has been a particular cooling in the relations of France and West Germany. On October 25 the substantial French opposition to an independent French nuclear deterrent attempted to oust the government of Premier Michel Debré by a motion of censure, which was defeated, thus giving the deterrent plan parliamentary approval. Meanwhile, a proposed plan for strengthening NATO, prepared at Secretary of State Herter's request by Robert R. Bowie, director of the Center of International Affairs at Harvard University, would make NATO the world's fourth atomic power, with its own nuclear deterrent force, and would also strengthen NATO's limited war capability. Placing stockpiles of nuclear warheads under NATO control would require a change in the U.S. law, which prohibits delivery of nuclear devices to other powers in peacetime, and requires U.S. control over stockpiles. This matter was thought to have been discussed recently by Secretary-General Paul-Henri Spaak of NATO and Eisenhower Administration officials, including the President. While some hoped that such a plan might decrease the French insistence on an independent nuclear capability, high-ranking Pentagon officials (especially from the Air Force) were reported to be resisting the proposal. They feel that problems of control would be crucial, since there could not be "fifteen fingers on the trigger." Advance agreement on conditions for sending nuclear weapons into action would be necessary, and discussions of the problem might paralyze the NATO command for a long time in the future, in addition to arousing new antagonisms. Another worry for European members of NATO is whether U.S. political developments and the unfavorable balance of payments may create pressure to decrease the U.S. ground force commitment in Europe.

British Bombers To Be Dispersed.—The British Royal Air Force plans to employ a considerable portion of its nuclear bombers on patrol flights to and from overseas bases at which nuclear weapons will be stockpiled, so that a surprise blow at Britain would not destroy her full nuclear potential. This plan has been adopted as less costly than a constant air alert. (*NYT*, 10/24)

Nuclear Submarine News.—The submarine *Seawolf*, the Navy's second nuclear-powered ship, was recommissioned with a new reactor on September 30, and the nuclear-powered submarine *George Washington* left Groton, Connecticut, October 27 to pick up its armed missiles at Charleston, S.C., before beginning ocean patrol duty. The submarine will have sixteen missiles, each with a warhead of greater destructive power than the first atomic bombs. They can be launched from positions below the surface of the water. The *Tullibee*, the first nuclear-powered Navy submarine designed to seek out and destroy enemy submarines, was commissioned November 9. . . . Queen Elizabeth launched the first British nuclear-powered submarine (also a "sub-killer"), the *Dreadnought*, on October 21, the day after Soviet Premier Khrushchev announced that the USSR has nuclear submarines capable of firing rockets with nuclear warheads. This was the first information from an official source concerning Soviet nuclear-powered, missile-armed submarines. . . . The British are interested in the U.S. missile submarines and would like to have American help in constructing them, but such help might create problems in relations with France, which would also like aid in building a nuclear navy. Both the U.S. and the British are also nervous about the highly vocal neutralist segment of the British population and how it would react to another cooperative military agreement with the U.S. (H. Baldwin, *NYT*, 10/21)

Carrier Launched.—The biggest ship ever built, the nuclear aircraft carrier *Enterprise*, was launched by the U.S. on September 24. It is equipped with a data processing and communications system that could evaluate an enemy threat and recommend counteraction. The final decision would be left to human beings, however.

WEAPONS DEVELOPMENT

Centrifuge Process for Producing U-235 Classified.—The West German government, in response to suggestions from the U.S., has classified as a state secret a relatively cheap method of producing uranium-235, developed by a group of German scientists. The process, which uses a gas centrifuge, was studied during World War II, but was discarded as less practicable than the gaseous diffusion process. The newly revived method may eventually be much less expensive than the present method, and this has led to concern about the possible entry of smaller and poorer nations into the atomic arms race. Although West Germany has now classified the process, two of the German machines had already been sold to Brazil, and the method is reportedly known also in Britain and the Netherlands, as well as the United States.

AEC

Model Laboratory to Argentina.—A complete laboratory showing peaceful atomic work in industry, medicine, and agriculture has been developed by the Oak Ridge Institute of Nuclear Studies and sent by the AEC to the Argentine Sesquicentennial Celebration. The exhibit includes an operating research and training reactor, and an operating gamma-ray facility. After the Argentine celebration the exhibit will go on tour through South America in its own portable building. Lecture-demonstrations will be given in Spanish and Portuguese. In each country local scientists will help present the display and do experiments.

Detector of Space Explosions Developed.—The Atomic Energy Commission has announced the development of a detector of nuclear explosions in space. The experimental equipment in operation at Los Alamos, New Mexico, detects fluorescence from atomic radiation up to about 33,000 miles in space by means of a narrow band filter and an optical detector mounted behind a wide-angle lens. It has worked successfully under clear weather

conditions, day and night, but has not been fully tested under cloudy conditions. If the system proves practical, it may become the basis for a world-wide network of 180 detection stations, as has been proposed by the U.S. at the test-ban negotiations. (*NYT*, 10/15)

CHEMICAL AND BIOLOGICAL WARFARE

Expenditures To Double.—According to Army sources, Department of Defense expenditures on chemical and biological warfare will more than double within a few years. The budget going to Congress in January will increase research and development funds to $76,000,000 from this year's $70,000,000, but within seven years the annual spending rate should reach $200,000,000. (*Seattle Times*, 11/2)

RADIATION

Windscale Accident.—A recent joint report by the British Atomic Energy Authority and the Agricultural Research Council on the October 1957 Windscale reactor accident gives details of the concentration of the strontium-89 and strontium-90 in the soil, grass, and other vegetation, and milk of nearby farms. Only for farms within two miles of the factory could it be concluded that the strontium-90 had come from the accident. The highest values (in a field adjacent to the pile) was about 60 times the national average, though much of this apparently resulted from emissions prior to the accident. For farms farther away it could not be established that levels were higher than for the rest of Great Britain. The evidence also suggests that the incorporation into food chains of strontium-90 released from the pile is only about one-third of that reported for bomb-produced strontium. (*Nature*, 9/24)

Riviera Protests Mediterranean Waste Dumping.—The French government on October 12 postponed the Atomic Energy Commission's plan to sink 6,500 barrels of radioactive waste in the Mediterranean 50 miles from shore between Antibes and Corsica, after protests by Prince Rainier of Monaco, the cities of Nice and Antibes, and Commander Jacques-Yves Cousteau, director of the Museum of Oceanography of Monaco. The final fate of the dumping project is uncertain.

Fisherman Nets Drum.—A Gloucester, Massachusetts, fisherman netted a 30-gallon drum containing low-level radioactive waste materials from the bottom of Massachusetts Bay on September 29. The drum and its concrete casing were intact, and the Atomic Energy Commission found radiation levels on its surface ranging from 0.1–0.7 mr/hr, well within the permissible limits of 200 mr/hr for the surface of such containers. The drum was hauled up from a depth of about 275 feet in a marked area which had been used for many years for disposal of explosives, chemicals, scrap steel, and until August 1959, packaged low-level radioactive wastes. At that time the license of the disposal firm, Crossroads Marine Disposal Corporation, was amended to require sea disposal at depths of at least 6,000 feet. The fisherman's drum was sent to Oak Ridge, Tennessee, for land burial, as is Crossroads Marine's current practice. There is no evidence to indicate that the drum had shifted from its orginal position.

SCIENCE AND SCIENTISTS

Nobel Prizes Awarded.—The 1960 Nobel Prize for Chemistry was awarded to Willard F. Libby of UCLA, former member of the Atomic Energy Commission, for his development of the radioactive carbon dating method, and the prize for physics was awarded to 34-year-old Donald A. Glaser of the University of California at Berkeley for his invention of the bubble chamber. Sir Macfarlane Burnet, professor of experimental medicine at Melbourne University, Australia, and Peter Brian Medawar, professor of zoology at University College, London, were announced as winners of the 1960 prize for physiology and medicine. They were honored for their discovery that a body can be made to tolerate foreign tissues. The Nobel Peace Prize Committee has announced that it will withhold the Peace Prize for 1960.

OUTER SPACE

Space Observatory To Be Developed.—National Aeronautics and Space Administration is contracting with Grumman Aircraft Engineering Corporation to develop two 1½-ton orbiting astronomical observatories. Telescopes on the space platforms will study X-rays, and ultraviolet and infrared rays, phenomena usually obscured by the earth's atmosphere, and the information will be transmitted to the ground. Plans are to launch the first observatory in late 1963 with an *Atlas-Agena B* missile. Several universities and observatories have planned projects for the space platform.

NEWS FROM ABROAD

Britain.—The Labour Party conference approved a resolution calling for Britain's unilateral nuclear disarmament and other measures that would take the country out of NATO, despite the vigorous opposition of Hugh Gaitskell and other party leaders. Gaitskell, since re-elected as party chief, is campaigning for a reversal at the next conference. The Conservative government, at its party conference, reaffirmed its support of NATO.

IAEA.—The fourth general conference of the International Atomic Energy Agency, chaired by Professor Georgi Nadjakov of Bulgaria, supported the U.S. position on the necessity for safeguards and controls on fissionable material transferred from one nation to another, but the proposal was approved over the objections of the Union of South Africa, India, and five other neutral Asian nations, as well as the Soviet bloc. Since a detailed plan for the safeguards had taken until this year to work out, it had not yet been put into operation. Instead, U.S. has made bilateral agreements to give or sell fissionable materials to other nations, and has made its own arrangements for safeguards. Though the plan was adopted, its value is uncertain. For example, the Union of South Africa can sell uranium ore in a bilateral arrangement to any nation which objects to the controls, as can the Soviet Union. The U.S. took the lead in organizing IAEA chiefly because of the hope that an effective system of international controls could be established through the agency, both to discourage the spread of atomic weapons, and to make a beginning toward general inspection for arms control. The argument of India and the other neutrals, supported by the USSR, was that the U.S. wants to impose controls on the underdeveloped nations, while the major atomic powers are left free of controls. As a partial answer to this criticism, Chairman John McCone of the U.S. AEC offered to place four American reactors under the control system. Though this was mostly a gesture, since the four reactors represent only a small part of American nuclear facilities, it strengthened the U.S. position. . . . The Soviet bloc introduced resolutions on disarmament and the test ban, and the U.S. took the position that these are extraneous issues. The admission of Communist China was rejected, but by a smaller margin than last year. . . . Director General Sterling Cole called attention to the agency's achievements in fellowships, scientific conferences, international health and safety standards, and its work in helping underdeveloped countries evolve realistic plans for using atomic energy. . . . It is generally felt that the IAEA is a useful organization in spite of its limited field of activity, and that there is still room for a good deal of work. The U.S. budget for IAEA amounts only to about $5 million a year (though it is larger than any other nation's contribution). The budget for American atoms-for-peace bilateral aid is only $1.5 for this year. (*Sc.* 10/7)

Norway.—The Halden boiling heavy water reactor produced steam for the first time on October 5, with an energy output of 2,000 thermal kilowatts. The reactor power will ultimately reach 20,000 kilowatts. The reactor is one of the three joint projects of the OEEC European Nuclear Energy Agency, with Norway and 11 other members of the OEEC, and also Finland, participating.

USSR.—Dr. Abram Joffe, Soviet physicist died October 14 at the age of 80. He specialized in work on solid state, including ferroelectricity, thermoelectricity, and semi-conductors. (*NYT*, 10/15)

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Letters to the Editor

(*Continued from inside front cover*)

says that human freedom must "intervene so seldom or so astutely as to leave the statistics of the particles still in conformity with the . . . mathematics of probability." This is unnecessary. Heisenberg has suggested that quantum principles may require supplementation when applied to organisms. Muller is ruling this out arbitrarily.

And he is going beyond any information he can possibly have, in implying that psychology has established a causal determination more stringent with respect to individual behavior than physics on the microlevel. No one has ever predicted precisely the actual behavior of any animal at any given moment. And when we look back and see that some "choice" of ours had its reasons, we are not seeing reasons for any concrete act, but for some selected feature of the act. And although it may have been an inevitable result of the conditions shortly before the act, it does not follow that it was inevitable from birth on, or that all other features of the act were inevitable.

If all that happens is the inevitable outcome of the past, then the entire universe, with all its arbitrary detail, is simply inexplicable. It is determinate, yet arbitrary, and there is no hint of when and how the selection among possible worlds was made. The real problem of "origins" is left wholly in the dark.

If, on the other hand, all choice, and indeed all causation, involves arbitrary elements, then the detailed arbitrariness of the world is leaking into it, so to speak, at every point. Our human, creative powers are merely high-level, intensive cases of this universal principle. The Neo-Darwinian account, which I accept, seems to fit this view better than the unqualified determinism which Muller espouses.

To maintain the view that freedom in some degree is universal requires no compromise. It can also be shown that Darwin's objections to theism are readily met if the determinism to which he was inclined (which is essentially statistical, not Newtonian, in its operating causal principles) is dropped. This implies that the crude dichotomy which Professor Muller sets up is not a sufficient instrument of analysis for the philosophical puzzles which he attacks.

CHARLES HARTSHORNE
Emory University
Atlanta, Georgia

The Weapons of Suicide

DEAR SIR:

I have been pondering the key statement in the movie, *On the Beach*. "The war started when people accepted the idiotic idea that peace could be maintained by arranging to defend themselves with weapons they couldn't possibly use without committing suicide." I wonder if we would convey meaning more accurately if instead of using the phrase, "weapons of mass destruction," we would use the phrase, "weapons of mass suicide."

WILLIAM M. ALEXANDER
California State Polytechnic College
San Luis Obispo, California

Chances of War

DEAR SIR:

Professor J. Glenn Gray's article on the chances of war in the October 1960 issue is typical of what one would expect from a professor of philosophy. My objection to the article is that he simply doesn't understand the type of mentality that will get us into a war. There are millions of Americans who honestly believe that if we hit the other side hard and first with hydrogen bombs, we'll kill so many of them that they will be unable to hit back. This suicidal, maniacal point of view, if accepted only in part, by a handful of government officials, could mean a cataclysm.

This is the problem. How do you convince these morons that no secret or sudden attack can possibly spare the United States a retaliation as great as that which we inflict? If Professor Gray had argued with these people, in restaurants, in streets, in colleges, he would recognize the problem. We have numerous exponents of all-out, immediate war with China and Russia—a huge army of people who think that we can inflict a catastrophe on the "enemy" and come away unscathed. But this problem is not answered or even discussed, by Professor Gray.

MORTIMER T. COHEN
New York, New York

COMING

SOUR WINE IN OLD BOTTLES	*Harry Kalven, Jr.*
CRISIS OF SECRECY	*John E. Moss*
PROBLEMS OF NEW STATES	*W. A. Lewis*
THE SPREAD OF NUCLEAR WEAPONS	*Frank Aiken*
NEW NATIONS AND THE SCIENTIFIC REVOLUTION	*David Apter*

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